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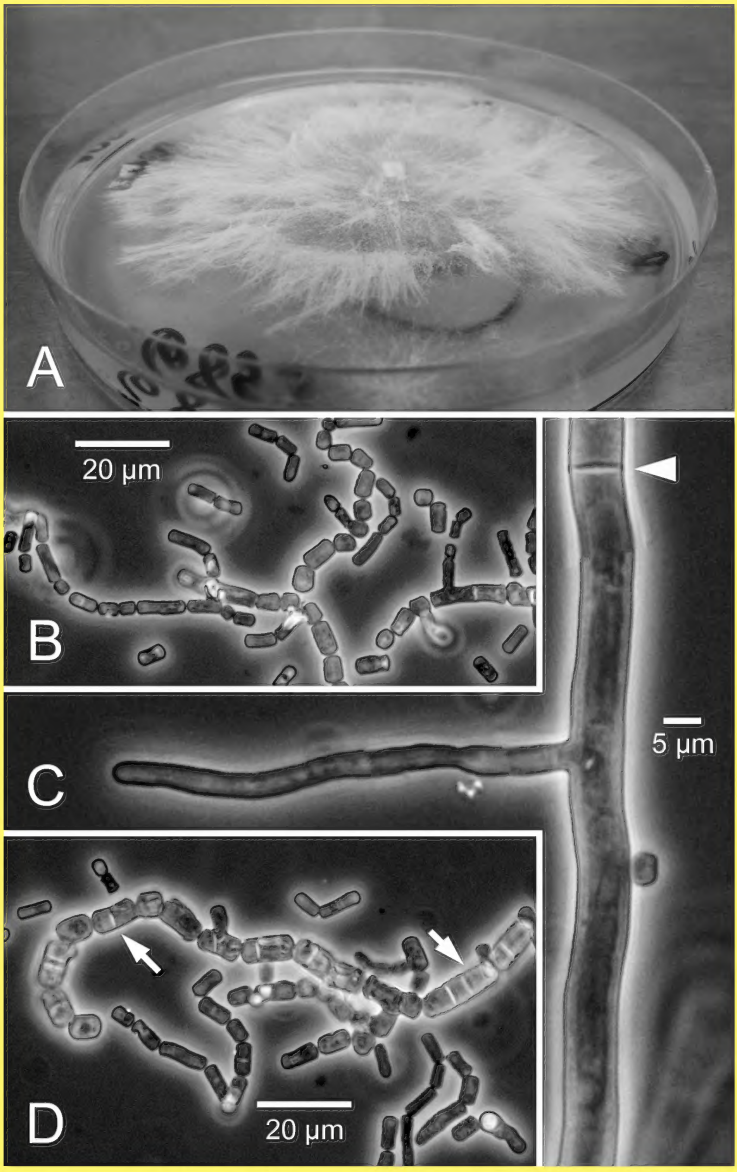

Flavodon ambrosius sp. nov.
(Simmons, Li, Bateman & Hulcr— FIG. 1, p. 281)

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MYCOTAXON

VOLUME ONE HUNDRED THIRTY-ONE (2) — TABLE OF CONTENTS

Cover section

Reviewers vii
Errata viii
From the Editor ix
Submission procedures xi

Research articles

Three new species of *Hemicorynespora* and *Solicorynespora* from southern China — Jian Ma, Ji-Wen Xia & Xiu-Guo Zhang 263

Four new *Humicola* species from soil in China — Yu-Lan Jiang, Yue-Ming Wu, Jun-Jie Xu, Yue-Hua Geng, Hong-Feng Wang & Tian-Yu Zhang 269

Flavodon ambrosius sp. nov., a basidiomycetous mycosymbiont of *Ambrosiodmus* ambrosia beetles — D. Rabern Simmons, You Li, Craig C. Bateman & Jiri Hulcr 277

Atrosynnema, a new hyphomycete from dead branches in China — Ji-Wen Xia, Ying-Rui Ma, Jian-Mei Gao, Xiu-Guo Zhang & Zhuang Li 287

Two new species of *Bactrodesmium* and *Dictyoaquaphila* from Mexico — Rosa M. Arias, Gabriela Heredia & Rafael F. Castañeda-Ruiz 291

Linkosia aquatica sp. nov. from submerged plant debris from Brazil — Lucas B. Conceição, Marcos Fabio Oliveira Marques, Luís Fernando Pascholati Gusmão, Josiane Santana Monteiro & Rafael F. Castañeda-Ruiz 297

Two new species of *Suillus* associated with larches in China — Xiao-Fei Shi, Fu-Qiang Yu, Rui Zhang & Pei-Gui Liu 305

First record of *Parasola lilatincta* from Pakistan — Shah Hussain, Najam-ul-Sahar Afshan & Habib Ahmad 317

Pseudocercospora picrasmicola sp. nov. and a new record of *P. paludicola* from China — Fengyan Zhai, Yingjie Liu & Yinglan Guo 325

Acrodictys, Corynespora, Karstenula, Oncopodium, and *Sporocadus:* new genera for Turkey — Elşad Hüseyin, Faruk Selçuk & Kadriye Ekici 331

Merismatium, *Porpidia,* and *Protoparmelia* spp. new for Turkey and Asia — Kenan Yazici & Ali Aslan 337

New *Bacidia, Opegrapha,* and *Rhizocarpon* records for Turkey and Asia — Kadir Kinalioglu & André Aptroot 345

Helicoma jianfenglingense sp. nov. and *Cubasina* and *Endophragmiella* species new to China
Jian-Mei Gao, Chun-Ling Yang, Jin-Ye Wang, Ji-Wen Xia, Ying-Rui Ma & Xiu-Guo Zhang 351

Evidence for *Gymnosporangium atlanticum* in Europe
José Luis Fernández, Imma Llorens & Pablo Alvarado 357

Asterolibertia moquileae comb. nov. on *Licania tomentosa* from Brazil
Jose Luiz Bezerra, Sílvia Patrícia Barbosa Araújo, André L. Firmino & Jadergudson Pereira 367

Gymnosporangium huanglongense sp. nov. from western China
Bin Cao, Cheng-ming Tian & Ying-mei Liang 375

New species of *Dictyochaeta* and *Wardomyces* from soil
Yu-Lan Jiang, Yue-Ming Wu & Tian-Yu Zhang 385

Xylohyphopsis aquatica sp. nov., a new aquatic hyphomycete from China
Jun-En Huang, Hai-Yan Song, Jian Ma, Guan-Xiu Guan & Dian-Ming Hu 391

Annulohypoxylon (*Xylariales*) from western Paraná, Brazi
Kely da Silva Cruz & Vagner G. Cortez 395

First record of *Pileolaria terebinthi* (*Pucciniales*) in Pakistan
B. Ali, Y. Sohail & A.S. Mumtaz 403

Lectotypification of the name *Umbilicaria esculenta*
Evgeny A. Davydov & Yoshihito Ohmura 407

Dinemasporium japonicum on *Polytrichum commune* from Korea
Ji-Hyun Park, Seung-Beom Hong, Young-Joon Choi & Hyeon-Dong Shin 413

Dictyoceratosporella wuzhishanensis sp. nov. from Hainan Province, China
Ji-Wen Xia, Chun-Ling Yang, Jin-Ye Wang, Ying-Rui Ma, Jian-Mei Gao & Xiu-Guo Zhang 419

Codinaea leomaiae sp. nov. from the Brazilian Atlantic Forest
Marcela A. Barbosa, Phelipe M.O. Costa, Elaine Malosso & Rafael F. Castañeda-Ruiz 423

Stachybotryna longispiralis sp. nov. from the Brazilian Atlantic Forest
Phelipe M.O. Costa, Marcela A. Barbosa, Marina A.G. Araújo, Elaine Malosso & Rafael F. Castañeda-Ruiz 429

Phaeodactylium cymbisporum sp. nov. from the Brazilian Atlantic Forest
Phelipe M.O. Costa, Marcela A. Barbosa, Marina A.G. Araújo, Elaine Malosso & Rafael F. Castañeda-Ruiz 435

Turkish truffles 2: eight new records from Anatolia
Todd F. Elliott, Aziz Türkoğlu, James M. Trappe & Mehrican Yaratanakul Güngör 439

New species and new records of the lichen genus *Fuscopannaria* from China Hua-Jie Liu, Jian-sen Hu & Qing-feng Wu 455

Four new morel (*Morchella*) species in the elata subclade (*M.* sect. *Distantes*) from Turkey Hatira Taşkin, Hasan Hüseyİn Doğan, Saadet Büyükalaca, Philippe Clowez, Pierre-Arthur Moreau & Kerry O'Donnell 467

Regional mycobiota new to the Mycotaxon website 483
Contribution to the macrofungal diversity of Yozgat province (Turkey)
Ibrahim Türkekul & Hakan Işik

Book reviews and notices Else C. Vellinga 485
The fungal flora in southwestern Japan: agarics and boletes
Terashima with Takahashi & Taneyama (eds)
Atlas of Chinese macrofungal resources Li, Li, Yang, Tolgor & Dai

Nomenclatural novelties and typifications proposed in Mycotaxon 131(2) 489

Reviewers — volume one hundred thirty-one (2)

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this quarter.

Reinhard Berndt
Uwe Braun
R.F. Castañeda-Ruiz
P.W. Crous
Cvetomir M. Denchev
Francisco das Chagas Oliveira Freire
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Errata from previous volumes

Volume 131(1)

cover, after line 5	add: Pamela R. Largent, *photographer*		
p. 1, line 4	for: *Traditional Chinese Medicine*	read: *Chinese Medicine*	
p. 5, line 11	for: 1212RJZAQ092	read: 1312RJZAQ092	
p. 8, line 17	for: Fungal Isolation'	read: Fungal isolation	
p. 11, line 18	for: *Aspergillus*	read: *A.*	
p. 111, line 17	for: (1894:)	read: (1894)	
p. 112, line 26	for: 40°Cto	read: 40°C to	
p. 135, line 4	for: Western China	read: Northwest China	
p. 136, line 20	for: Western China	read: Northwest China	
p. 137, line 21	for: Xiao Q Zi	read: Xiao Qu Zi	

From the Editor-in-Chief

Mycotaxon & the space-time continuum — It was not our intention to deliver the April–June issue two months late (in August), but a series of misfortunes in May and June conspired to delay our nomenclatural editorial reviews. Fortunately, Nomenclature Editor Pennycook is once again healthily churning out his nomenclatural revisions and final submissions are cascading in for my final editorial review, approval, and PDF conversions.

One problem confronting any journal is whether to wait until a certain page minimum is reached (in our case, 300 pages) or issue a publication on time irrespective of page number. As most readers now subscribe to our online journal, there is little to be gained by waiting for a page minimum before publishing an issue. Our hard-print copies dictate the date of publication, and the printed issues are generally mailed within one week after your Editor-in-Chief sends the PDFs to Webmaster Noni Korf and Business Manager Hannes Maddens for print and web preparation. There is generally a two–three week interval before Ingenta finally posts the issue online.

Henceforth our goal is to publish each issue within the quarter emblazoned on its cover. This may mean that the July–September issue will be small, but our hope is to deliver the papers on time. As we've been hoping to accomplish this for the past twelve years, wish us luck!

Mycotaxon 131(2) contains 29 papers by 90 authors (representing 12 countries) and revised by 45 expert reviewers.

Within its pages are one new genus and species (*Atrosynnema digitosporum* from China) and 29 other species new to science representing *Annulohypoxylon, Codinaea, Linkosia, Phaeodactylium,* and *Stachybotryna* from Brazil; *Bactrodesmium* and *Dictyoaquaphila* from Mexico; *Dictyoceratosporella, Dictyochaeta, Fuscopannaria, Helicoma, Hemicorynespora, Humicola, Pseudocercospora, Solicorynespora, Suillus, Wardomyces,* and *Xylohyphopsis* from China; *Flavodon* from the U.S.A.; and *Morchella* from Turkey.

In addition to range extensions and/or new hosts for previously named taxa in China, Korea, Pakistan, Turkey, and Spain, we also offer new combinations in *Asterolibertia* from Brazil and a lectotypification of *Umbilicaria esculenta.*

Warm regards,

Lorelei L. Norvell
Editor-in-Chief
30 July 2016

publication date for volume one hundred thirty-one (1)

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4—Final editorial review & press preparation: Files not ready for publication will be rejected or returned to authors for further revision; the *Editor-in-Chief* gives tentatvely approved manuscripts a final grammatical and scientific review before converting all files into publishable format. The PDF proof, bibliographic citation, and nomenclatural entries are sent to all coauthors for final inspection prior to publication. Thereafter, the *Editor-in-Chief* corrects only processing or editorial errors prior to publication but will list corrections of author errors in the Errata of a subsequent volume for no charge. Authors are expected to arrange payment of page charges and optional open access fees with the *Business Manager* <subscriptions@mycotaxon.com> at this time.

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Three new species of *Hemicorynespora* and *Solicorynespora* from southern China

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Abstract — Three new hyphomycetes were collected from decaying twigs of unidentified plants in southern China. *Hemicorynespora obovoidea* sp. nov., *Solicorynespora jinggangshanensis* sp. nov., and *S. lushanensis* sp. nov. are described, illustrated, and compared with closely related taxa.

Key words — anamorphic fungi, saprobic fungi, taxonomy

Introduction

During ongoing surveys of saprobic microfungi from forests of southern China, several interesting *Corynespora*-like taxa were found on decaying twigs. Among these were three species having the morphological features typical of *Hemicorynespora* M.B. Ellis (Ellis 1972) and *Solicorynespora* R.F. Castañeda & W.B. Kendr. (Castañeda-Ruíz & Kendrick 1990). They differ significantly from previously described species in several morphological features, and therefore are described here as new to science.

Hemicorynespora obovoidea Jian Ma & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 814891

Differs from all other *Hemicorynespora* species by its obovoid, asymmetrically 1-septate conidia.

Type: China, Guangdong Province: Liuxihe National Forest Park, on decaying twigs of an unidentified broadleaf tree, 10 July 2014, J. Ma (**Holotype**, HJAUP M0109).

Etymology: refers to the obovoid conidial shape.

Colonies on natural substrate effuse, brown to dark brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched,

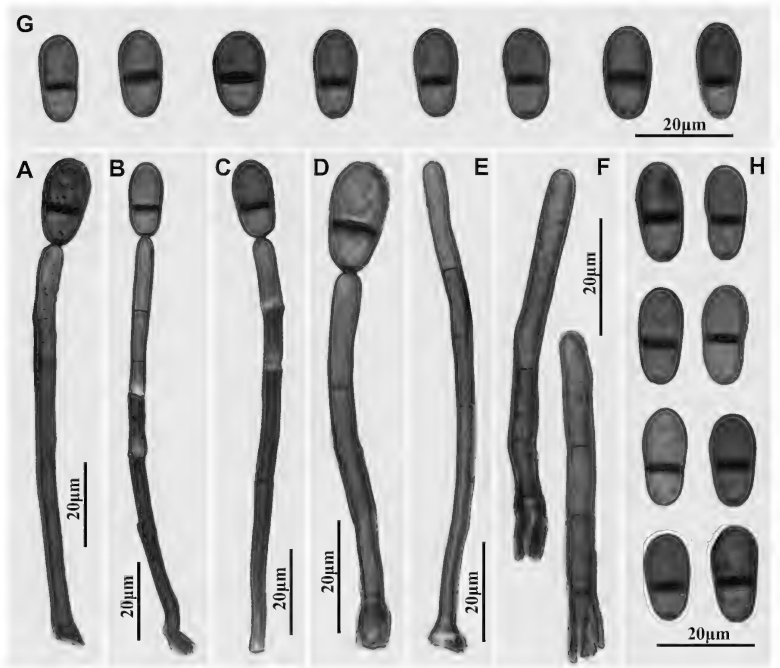

Fig. 1. *Hemicorynespora obovoidea* (holotype, HJAUP M0109): A–D. conidiophores and conidia; E, F. conidiophores; G, H. conidia.

septate, pale brown to brown, smooth hyphae. Conidiophores macronematous, mononematous, single, erect, unbranched, straight or flexuous, cylindrical, brown to dark brown, smooth, septate, 55–110 × 4–5.5 μm. Conidiogenous cells monotretic, integrated, terminal, cylindrical, brown, smooth, 16.5–34.5 × 4.5–5.5 μm, with 0–1 cylindrical percurrent extension. Conidial secession schizolytic. Conidia solitary, acrogenous, dry, obovoid, smooth-walled, brown, asymmetrically 1-septate, 16.5–20.5 × 8–11 μm, 1.5–2.5 μm wide at the truncate base.

Comments—Ellis (1972) established *Hemicorynespora* with two species, *H. deightonii* M.B. Ellis (type species) and *H. mitrata* (Penz. & Sacc.) M.B. Ellis. The genus is characterized by solitary, acrogenous, mitre-shaped, limoniform, obovoid or ellipsoidal, 0–1-septate, smooth conidia seceding schizolytically from integrated, terminal, monotretic, determinate or percurrently elongated conidiogenous cells (Ellis 1972, Seifert et al. 2011). Subsequently, 10 additional species have been reported in *Hemicorynespora* (Ellis 1972, Matsushima 1981, Holubová-Jechová 1987, Subramanian 1995, Mercado et al. 1997, Sivanesan &

Chang 1997, Delgado et al. 2007, Ma et al. 2012a). However, Ma et al. (2012a) excluded *H. obclavata* Subram. (with 2-septate conidia) and *H. multiseptata* Sivan. & H.S. Chang (with 4–5-septate conidia) from the genus; thus *Hemicorynespora* currently contains 10 recognized species. Only *H. clavata* G. Delgado et al. and *H. dimocarpi* Jian Ma & X.G. Zhang have previously been reported from China (Ma et al. 2012a).

Hemicorynespora obovoidea superficially resembles *H. ovata* Subram., which differs by its aseptate conidia (Subramanian 1995).

Solicorynespora jinggangshanensis Jian Ma & X.G. Zhang, **sp. nov.** Fig. 2

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Differs from *Solicorynespora melicopes* by its smaller, predominately 6-septate conidia with the basal cell longer than the second cell and from *S. obclavata* by its wider conidia with a shorter rostrum and the basal cell longer than the second cell.

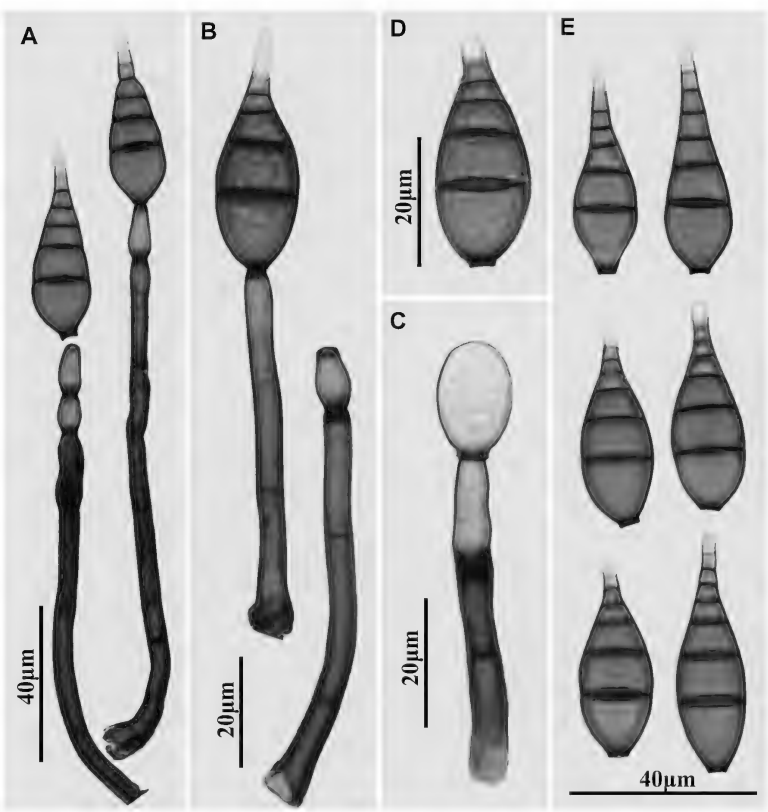

Fig. 2. *Solicorynespora jinggangshanensis* (holotype, HJAUP M0290): A, B. conidiophores and conidia;. C. conidiophore with developing conidium; D, E. conidia.

Type: China, Jiangxi Province: Jinggangshan Mountain, on decaying twigs of an unidentified broadleaf tree, 6 Nov. 2014, J. Ma (**Holotype**, HJAUP M0290).

Etymology: refers to the locality where the type specimen was found.

Colonies on natural substrate effuse, brown to dark brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, single, erect, straight or flexuous, unbranched, smooth, septate, brown to dark brown, 60–145 × 5–6 μm. Conidiogenous cells monotretic, integrated, terminal, cylindrical or lageniform, brown to pale brown, smooth, 11.5–22.5 × 4.5–6.5 μm, with 0–3 percurrent proliferations. Conidial secession schizolytic. Conidia solitary, dry, acrogenous, obclavate, rostrate, smooth, brown, 5–7-euseptate (mostly 6-septate), 35.5–51 × 13.5–15.5 μm, 3.5–4.5 μm wide at the truncate base, apex extended into a subhyaline to pale brown rostrum, 2.5–3.5 μm wide.

Comments—Castañeda-Ruíz & Kendrick (1990), who re-examined the genus *Corynespora* Güssow using conidial septation as the circumscribing character, erected the segregate genus *Solicorynespora* to accommodate those species previously described in *Corynespora* but with solitary, euseptate phragmoconidia (McKenzie 2010, Ma et al. 2012b, Hernández-Restrepo et al. 2014). Thus far, 22 species have been described in or transferred to the genus (Hernández-Restrepo et al. 2014, Ma et al. 2014).

Of the known species, *Solicorynespora jinggangshanensis* is most similar to *S. melicopes* Jian Ma & X.G. Zhang and *S. obclavata* (Dyko & B. Sutton) R.F. Castañeda & W.B. Kendr. in conidial shape, but *S. melicopes* differs by its larger, predominately 5-septate, occasionally distoseptate conidia (77–94 × 19.5–27 μm); with the longest cell second from the base (Ma et al. 2012b); and *S. obclavata* differs by its narrower conidia (9.5–11 μm wide) with a longer rostrum and the longest cell second from the base (Castañeda-Ruíz & Kendrick 1990).

Solicorynespora lushanensis Jian Ma & X.G. Zhang, **sp. nov.** Fig. 3

MycoBank MB 814893

Differs from *Solicorynespora linderae* by its smooth, smaller conidia with more septa.

Type: China, Jiangxi Province: Lushan Mountain, on decaying twigs of unidentified broadleaf trees, 8 Nov. 2014, J. Ma (**Holotype**, HJAUP M0199).

Etymology: refers to the locality where the type specimen was found.

Colonies on natural substrate effuse, brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae. Conidiophores macronematous,

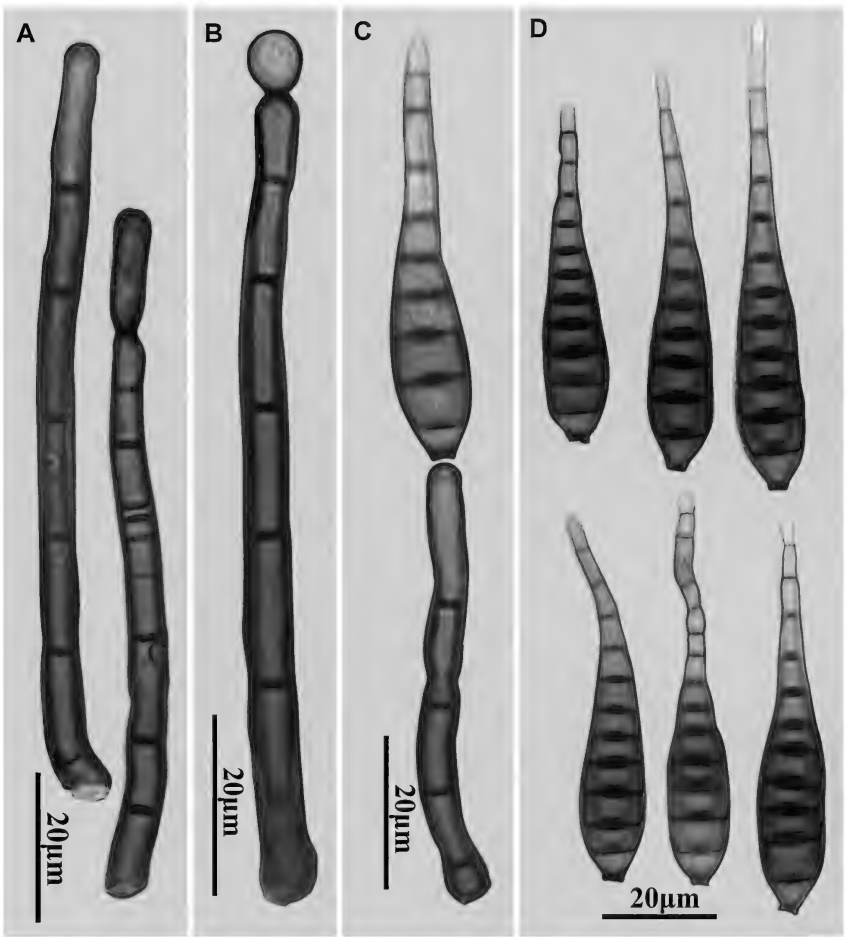

Fig. 3. *Solicorynespora lushanensis* (holotype, HJAUP M0199): A. conidiophores; B, C. conidiophores and conidia; D. conidia.

mononematous, solitary or in groups, erect, straight or flexuous, unbranched, smooth, brown, 55–115 × 5–6 μm. Conidiogenous cells monotretic, integrated, terminal, cylindrical, brown, smooth, 9.5–20.5 × 4–5 μm, sometimes with 1 percurrent extension. Conidial secession schizolytic. Conidia solitary, dry, acrogenous, obclavate, tapering towards the apex, smooth, brown, paler towards the apex, 9–13-euseptate, 56–78 × 10–12 μm, tapering to 2–3 μm near the apex, 2.5–3.5 μm wide at the truncate base.

Additional specimen examined: **China**, **Jiangxi Province**: Lushan Mountain, on decaying twigs of unidentified broadleaf trees, 8 Nov. 2014, J. Ma (HJAUP M0190).

Comments—*Solicorynespora lushanensis* is similar in conidial shape to *S. linderae* Jian Ma & X.G. Zhang, which differs by its larger, 7–9 septate conidia (100–130 × 12.5–15.5 μm) with a verrucose basal cell and a pale brown, aseptate rostrum (Ma et al. 2012b).

Acknowledgments

The authors express gratitude to Dr. R.F. Castañeda-Ruíz and Dr. Eric H.C. McKenzie for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review. This project was supported by the National Natural Science Foundation of China (No. 31360011) and the Education Department of Jiangxi Province of China (No. GJJ13282).

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Four new *Humicola* species from soil in China

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Abstract — *Humicola chinensis*, *H. irregularis*, *H. pyriformoides*, and *H. tibetensis* spp. nov. from soil in China, are described, illustrated, and compared morphologically with similar species. The type specimens (dried cultures) and living cultures are deposited in the Herbarium of Shandong Agricultural University: Plant Pathology (HSAUP).

Key words — aleuriospores, anamorphic fungi, hyphomycetes, taxonomy

Introduction

Humicola was established by Traaen (1914) for two species of fungi with hyaline hyphae, *Humicola fuscoatra* Traaen (type species) and *H. grisea* Traaen. Later, more species were included, although those with pigmented hyphae did not fit within Traaen's original circumscription. Fassatiová (1967) emended the diagnosis of this genus and constructed a key for the determination of *Humicola* species. She pointed out that according to the taxonomic opinions of Hughes (1953) and Subramanian (1962) hyphal color was not a decisive feature and that only fungi with the definitely expressed character of forming aleuriospores could be included in the genus. De Bertoldi (1976) subsequently concluded that aleuriospore size was the most effective and stable diagnostic morphological character in *Humicola*.

During an investigation of the soil dematiaceous hyphomycetes in China, four fungi were obtained that grew on potato dextrose agar (PDA) and possessed

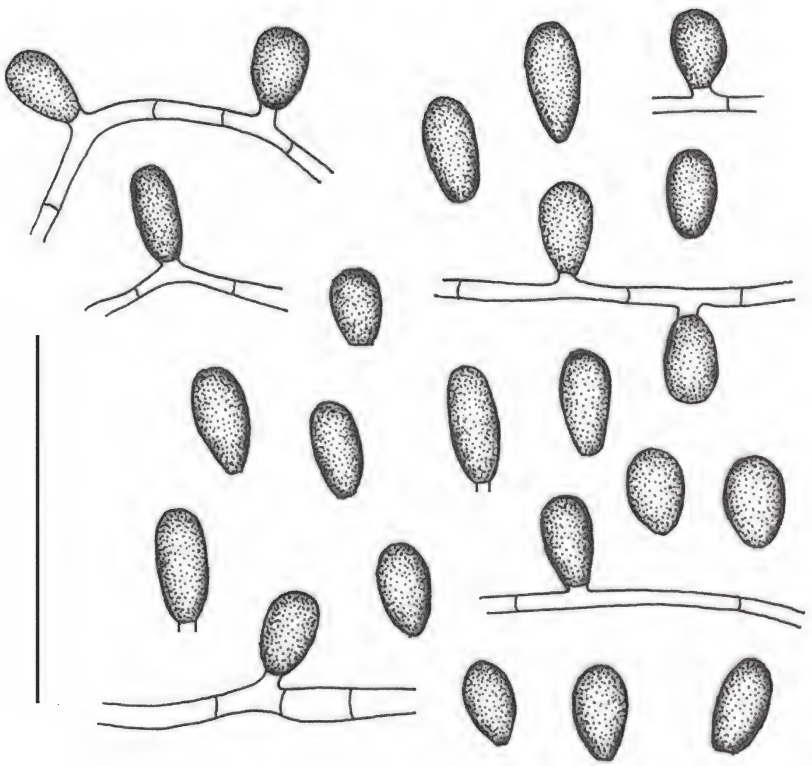

FIG. 1. *Humicola chinensis* (ex holotype HSAUP II_{04}6065). Conidia and conidiophores. Scale bar = 25 μm.

the typical *Humicola* characters. They did not match with other known species in this genus and are therefore proposed as new species.

Humicola chinensis Y.L. Jiang & T.Y. Zhang, **sp. nov.** FIG. 1

MYCOBANK MB 801834

Differs from *Humicola piriformis* and *H. pyriformoides* by its yellowish colony color and its narrower, obovoid to oval conidia.

TYPE: China, Hubei Province, Enshi, from soil of a lotus pond, 18 Oct. 2004, Y.L. Jiang (**Holotype**, HSAUP II_{04}6065).

ETYMOLOGY: in reference to the country where the specimen was isolated.

COLONIES on PDA effuse, pale greyish yellow, reverse yellowish brown, reaching 4–5 cm in diameter in 2 weeks at 25 °C. MYCELIUM superficial and immersed; hyphae hyaline, branched, septate, smooth, 1–3 μm wide. CONIDIOPHORES

arise on long aerial hyphae, lateral, unbranched, 0.5–4 µm long. Conidia formed singly either directly on the sides of vegetative hyphae or on short lateral conidiophores, smooth, unicellular, obovoid or sometimes oval, rounded at the distal end, truncate at the base, often with a small portion of the conidiogenous cell attached, pale to dark brown, 4.5–9 × 3–4.5 (commonly 6.3 × 3.5) µm, they often become detached. No intercalary chlamydospores or enteroblastic phialidic conidia present.

Comments: In conidial morphology *Humicola chinensis* resembles *H. piriformis* De Bert. and *H. pyriformoides* (see below), but *H. piriformis* differs by its brown-black colony color, its globose or pyriform conidia (7–7.2 × 7.1–7.5 µm), and its enteroblastic phialidic conidia and intercalary chlamydospores (De Bertoldi 1976), and *H. pyriformoides* differs by its pale grey colony color and mostly spherical or subspherical conidia (4–13 µm diam.).

Humicola irregularis H.F. Wang & T.Y. Zhang, sp. nov. Fig. 2

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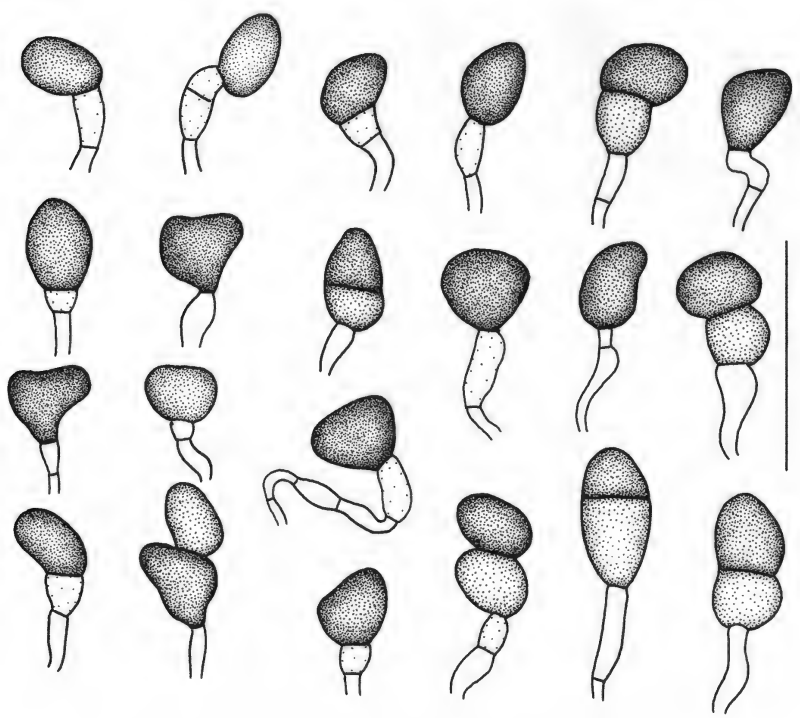

Fig. 2. *Humicola irregularis* (ex holotype HSAUP II_{06}5173). Conidia and conidiophores. Scale bar = 25 µm.

Differs from all other *Humicola* species by its irregularly shaped 1–3 celled conidia.

Type: China, Qinghai Province, Huzhu County, from a mountain soil, H.F. Wang (**Holotype**, HSAUP II_{06}5173 (dried culture); **isotype**, HMAS 196247).

Etymology: in reference to the irregular shape of the conidia.

Colonies on PDA effuse, floccose or hairy, dark grey to black, reverse black, reaching 5–6 cm in diameter in 2 weeks at 25 °C. Mycelium mostly superficial; hyphae hyaline, branched, septate, smooth, 1.3–2.5 µm wide. Conidiophores micronematous, unbranched, hyaline, septate, smooth, straight or flexuous, 0.5–3 µm wide, up to 34.5 µm long. Conidiogenous cells monoblastic, terminal or lateral, cylindrical or slightly swollen. Conidia 1–3 (commonly 1–2) celled, irregular in shape: cuneiform, broadly obovoid or other shapes, brown to dark brown, smooth, unicellular 3.5–11 × 3–6 µm (commonly 4.5 × 4 µm), bicellular 9.5–14 × 6.5–7.5 µm. No intercalary chlamydospores or enteroblastic phialidic conidia present.

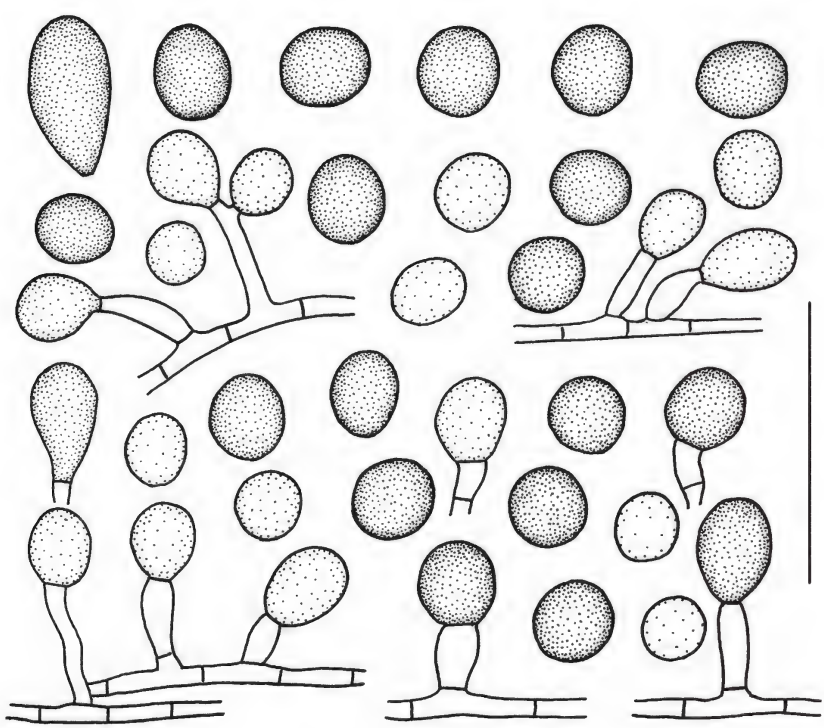

Fig. 3. *Humicola pyriformoides* (ex holotype HSAUP II_{04}2811). Conidia and conidiophores. Scale bar = 25 µm.

Humicola pyriformoides J.J. Xu & T.Y. Zhang, **sp. nov.** FIG. 3

MycoBank MB 801837

Differs from *Humicola piriformis* by its paler colony color and wider conidia.

TYPE: China, Fujian Province, Pingtan, from soil of a rice field, J.J. Xu (**Holotype**, HSAUP $II_{04}2811$).

ETYMOLOGY: in reference to the similarity of the conidia to those of *Humicola piriformis*.

COLONIES on PDA effuse, velvety or cottony, at first white, gradually becoming pale grey, reverse pale brown, reaching a diameter of 2–5 cm in 2 weeks at 25 °C. MYCELIUM superficial and immersed; hyphae hyaline to subhyaline, branched, septate, smooth, 1–3.5 µm wide, sometimes forming simple mycelial ropes. CONIDIOGENOUS CELLS monoblastic, terminal or lateral, hyaline to pale brown, non-septate, smooth, 1–21 × 3–4.5 µm. CONIDIA solitary, smooth, unicellular, pale brown to brown, mostly spherical or subspherical, 4–13 µm in diameter, or sometimes pyriform, 4–13 × 3–7 µm. No intercalary chlamydospores or enteroblastic phialidic conidia present.

COMMENTS: In conidial morphology, *Humicola pyriformoides* is close to *H. piriformis*, which differs by its dark brown to black colored colonies, its narrower conidia (7–7.2 × 7.1–7.5 µm), and its production of small enteroblastic phialidic conidia and intercalary chlamydospores (De Bertoldi 1976).

Humicola tibetensis Y.H. Geng & T.Y. Zhang, **sp. nov.** FIG. 4

MycoBank MB 801838

Differs from *Humicola grisea* by its smaller conidia.

TYPE: China, Tibet: Changdu County, altitude 3600 m, from a broadleaf-conifer mixed forest soil, 1 Jul. 2006, Y.H. Geng (**Holotype**, HSAUP $II_{06}1202$ (dried culture); **isotype**, HMAS 196250).

ETYMOLOGY: in reference to the region where the specimen was collected.

COLONIES on PDA effuse, cottony, first white then gradually becoming pale brown to greyish brown, reverse slightly paler, reaching a diameter of 2–5 cm in 2 weeks at 25 °C. MYCELIUM superficial and immersed; hyphae hyaline to subhyaline, branched, septate, smooth, 1–1.5 µm wide. CONIDIOPHORES differentiation inconspicuous. CONIDIA acrogenous or pleurogenous, solitary, broadly obovoid, spherical to subspherical, pale brown, thick-walled, smooth, 6.5–13.5 × 6–11.5 µm. Intercalary chlamydospores ellipsoidal to broadly ellipsoidal, pale brown, 6.5–10 × 6.5–7 µm. Enteroblastic phialidic conidia are produced by a simple, hyaline and smooth phialide, unicellular, spherical or ellipsoidal, pale brown to brown, smooth, rarely catenate, 3–5 µm in diameter.

COMMENTS: In producing typical aleuriospores, intercalary chlamydospores and phialospores and in its conidial morphology, *H. tibetensis* resembles

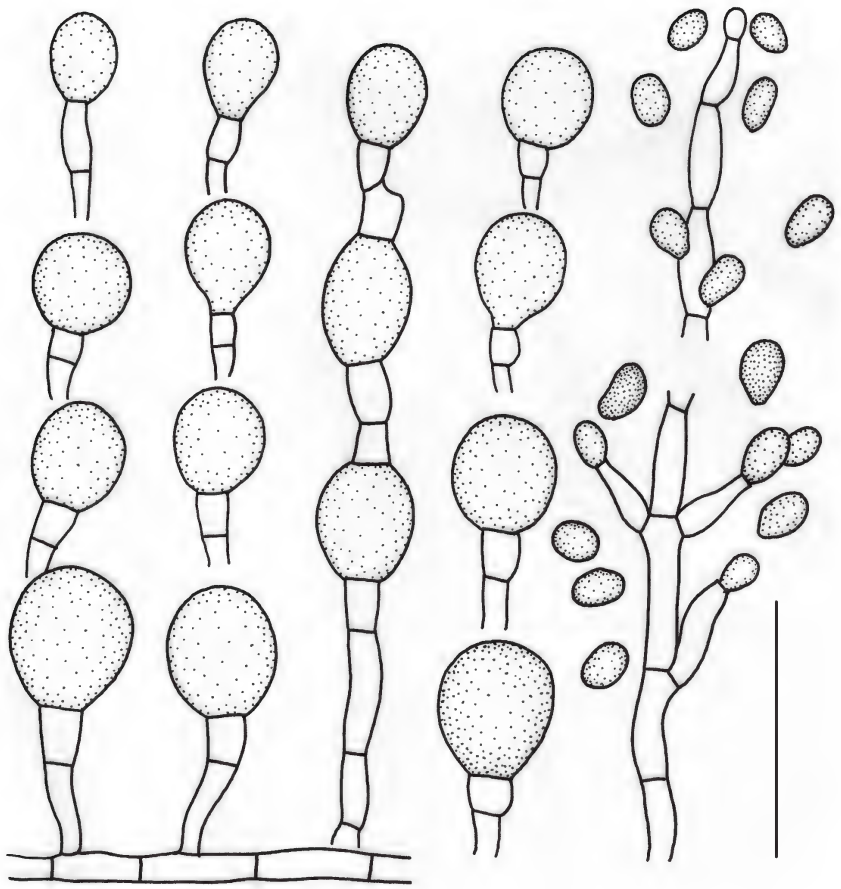

FIG. 4. *Humicola tibetensis* (ex holotype HSAUP $II_{06}1202$).
Conidia, conidiophores, phialides, and phialospores. Scale bar = 25 μm.

H. grisea, which differs by its larger conidia (12–17 μm diam.) and its catenate phialospores (Traaen 1914).

Acknowledgments

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Flavodon ambrosius sp. nov., a basidiomycetous mycosymbiont of *Ambrosiodmus* ambrosia beetles

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Abstract — Pure fungal cultures recovered from mycangia and fungal gardens of three *Ambrosiodmus* species were identified as a basidiomycetous fungus within the *Polyporales*. Culture-independent molecular analysis of the mycangia indicated that this fungus is the dominant symbiont transported by these beetles, and molecular phylogenetic analyses placed this fungus in a lineage with *Flavodon flavus*. We describe *Flavodon ambrosius* as a new species based on its phylogenetic position in relation to *F. flavus*, its role as a mycosymbiont rather than a free-living saprophyte, and its mode of asexual reproduction via arthroconidia.

Key words — *Basidiomycota*, nuclear ITS rDNA, 28S rDNA

Introduction

Flavodon Ryvarden (Ryvarden 1973) was described as a monotypic genus to accommodate *Irpex flavus* Klotzsch (Klotzsch 1833), whose classification had previously been questioned by Maas Geesteranus (1967). *Flavodon flavus* (Klotzsch) Ryvarden is a resupinate to conchate species of white-rot fungus in *Polyporales* with a hymenium that is dominantly poroid in resupinate forms but ages to hydnoid and which produces slightly ellipsoid, hyaline spores. The species is distinguished from related taxa in its yellow color that reacts to KOH by turning brown (Maas Geesteranus 1967). The hyphal system is dimitic, with thin generative and thickened skeletal hyphae possessing simple septa (Maas Geesteranus 1967) but otherwise morphologically unadorned at the microscopic level. Corner (1987), however, proposed monomitic *Polyporus cervinogilvus* Jungh. as "*Flavodon cervinogilvus*" (Jungh.) Corner (an invalid

name, lacking a basionym reference), thus opening interpretation of *Flavodon* to include monomitic and dimitic hyphal systems.

Flavodon is not uncommon in southern Asia from Pakistan to the Philippines (Maas Geesteranus 1967, Ryvarden & Johansen 1980, Corner 1987), tropical Africa to South Africa (Maas Geesteranus 1967, Ryvarden & Johansen 1980), and Australia (Ryvarden & Johansen 1980). *Irpex flavus* (the type species of *Flavodon*) was described from a North American specimen (Klotzsch 1833), but Ryvarden (1973) speculated that this locality might be a mislabeling error, perhaps from Mauritius (Indian Ocean). Gilbertson & Adaskaveg (1993) provided the first record of "*F. cervinogilvus*" in the United States from trees on the eastern coast of the Island of Hawai'i, and since then Miettinen et al. (2012) molecularly characterized a culture of *F. flavus* from Jamaica and placed the species alongside *Irpex lacteus* (Fr.) Fr. (Fries 1828), which is in the phlebioid clade of the *Polyporales* (Binder et al. 2013).

As part of an investigation into the mycosymbionts of *Ambrosiodmus* ambrosia beetles (*Coleoptera*, *Curculionidae*, *Scolytinae*, *Xyleborini*) in Florida, USA, Li et al. (2015) isolated fungi from mycangia of *A. lecontei* Hopkins, *A. minor* (Stebbing), and *A. rubricollis* (Eichhoff) from both stages of the ambrosia fungal life cycle: from the beetle mycangia as well as from their fungal gardens. To identify the fungi, Li et al. (2015) obtained ribosomal DNA (rDNA) sequences from both cultured isolates and culture-independent analyses of beetle mycangia, and these rDNA sequences identified the beetle mycosymbiont that dominated the mycangial fungal community as a relative of *Flavodon flavus*, as characterized by Miettinen et al. (2012). Additionally, microscopic examination of the fungus in culture and in situ in mycangia (Li et al. 2015) revealed hyphae with simple septa similar to those of the *Flavodon* type species, *F. flavus*, but no reproductive structures were observed.

Molecular and microscopic analyses indicated that this new fungus is a stable symbiont with *Ambrosiodmus* species and is horizontally transported from one generation to the next to act as a nutrient source via growth in the beetles' natal galleries in woody substrates. However, the two known *Flavodon* species have been observed only as saprophytic and free-living. Our new fungus, the first basidiomycetous mutualistic symbiont of ambrosia beetles, is proposed here as *Flavodon ambrosius*.

Materials & methods

Morphology of fungal cultures

Culture Hulcr 6853 from *Ambrosiodmus minor* was selected from analysis of Li et al. (2015) for morphological examination and typification. Subcultures were inoculated onto fresh BD Difco™ potato dextrose agar (PDA) medium, which was strengthened with

additional agar (5 g/L). Petri dishes (100 × 15 mm) of inoculated media were incubated at 25 °C until biomass had extended from the inoculation site to the edge of the dish (~4–5 d). Hyphae and arthroconidia were aseptically removed from the agar dishes, examined on glass slides, and photographed with an Olympus BX53F microscope equipped with phase optics and a ProgRes® SpeedXT core 3 camera (Jenoptik Optical Systems) using ProgRes® CapturePro 2.8.8. Aseptate arthroconidia (n = 20) were measured from which means (± standard deviations) were calculated.

Molecular phylogenetic analyses

We selected 28S rDNA sequences from Miettinen et al. (2012) that corresponded to the "*Byssomerulius* family", which included *Flavodon flavus* and related taxa. We aligned these sequences with those from cultured and culture-independent *Ambrosiodmus*-associated fungi (Li et al. 2015) using default settings in Geneious version 7.1.8 (http://www.geneious.com, Kearse et al. 2012). We used the Akaike information criterion (AIC) in jModeltest 0.1.1 (Guindon & Gascuel 2003, Posada 2008) to select the appropriate nucleotide substitution model. We conducted a maximum likelihood (ML) phylogenetic analysis with the model parameters in GARLI 2.01 (Zwickl 2006) to determine the best tree topology. We calculated bootstrap support values in GARLI from 100 search replicates, which we summarized with SumTrees (Sukumaran & Holder 2010). We conducted Bayesian phylogenetic analysis with the same parameters in MrBayes 3.1.2 (Ronquist & Huelsenbeck 2003), in which two runs of four chains each were executed simultaneously for 1M generations, sampling every 100 generations. We summarized 7501 trees retained after a burn-in of 2500 trees in SumTrees to compute Bayesian posterior probabilities (BPP).

Taxonomy

Flavodon ambrosius D.R. Simmons, You Li, C.C. Bateman & Hulcr, **sp. nov.** Fig. 1

MycoBank MB 813875

Differs from other *Flavodon* species by participating in a mutualistic symbiosis with ambrosia beetles and by the formation of arthroconidia from vegetative hyphae in pure culture on agar medium.

Type — USA, Florida, Alachua County, Gainesville, 29°37′16″N 82°22′32″W), extracted from preoral mycangia of *Ambrosiodmus minor* caught by light-trapping, 12 Nov 2014, Hulcr 6853 (**Holotype**, BPI 893213; ex-type culture, ATCC TSD-21; GenBank KR119072, KR119075, KR119078).

Etymology — *ambrosius* (Lat.): referring to the symbiotic relationship of this fungus with an ambrosia beetle genus.

Colonies on PDA white, yellowing with age; mycelium along surface of agar projected aerially, cottony, irregular at margins; hyphae monomitic with simple septa, hyaline, smooth, with narrow hyphae (3–4.5 µm wide) branching from wide hyphae (7–8 µm wide). Arthroconidia hyaline; cylindrical, aseptate (but may appear septate due to incomplete fragmentation), either (2.9–) 5.1–9.5(–12.7) µm long (produced by narrow hyphae) or (4.4–)5.2–8.4(–10.2)

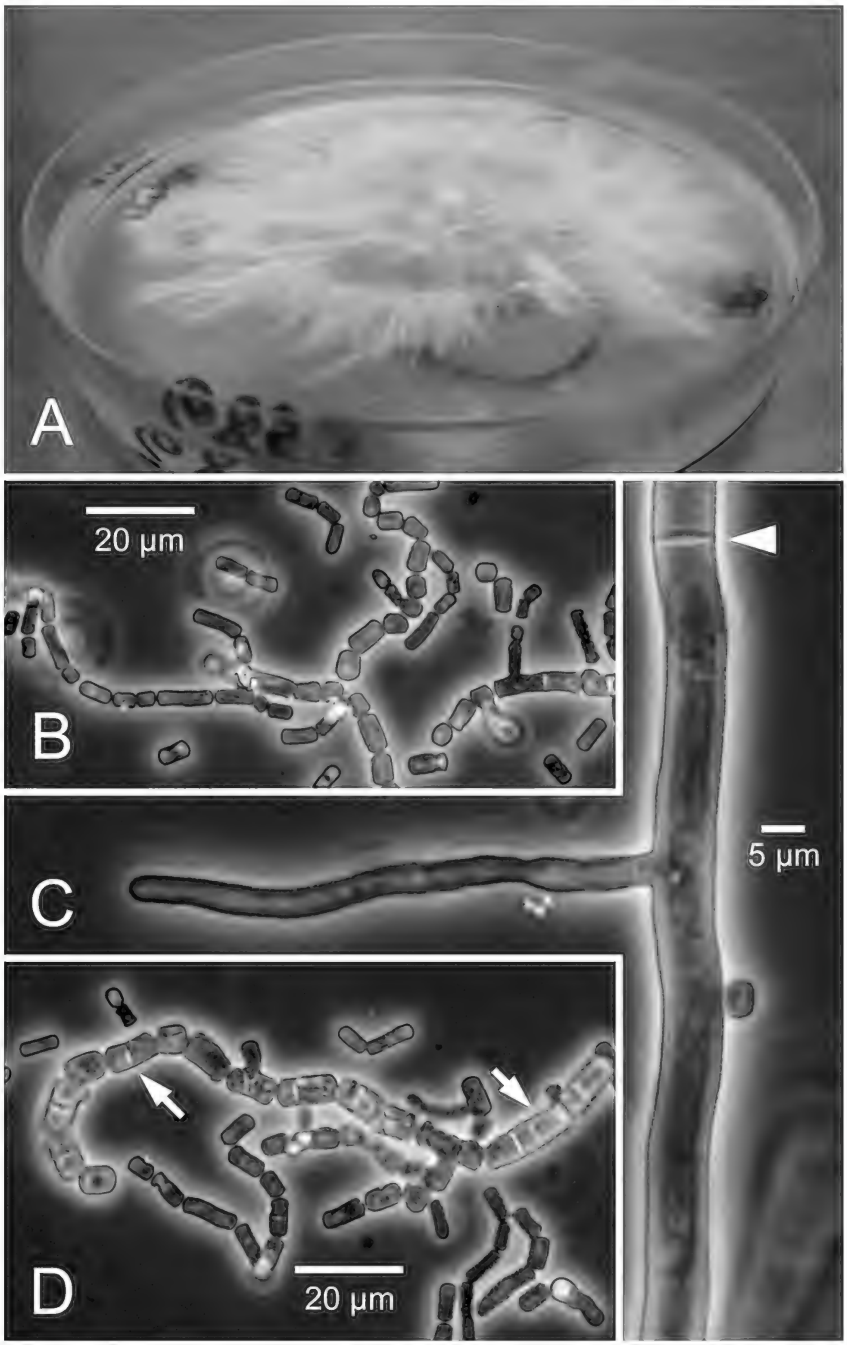
µm long (produced by wide hyphae). Sexual morph not observed. Associated with ambrosia beetles of tribe *Xyleborini*.

Additional specimens examined for sequence data — **USA, Florida**, Alachua County, Gainesville, 29°37′16″N 82°22′32″W, extracted from preoral mycangia of *Ambrosiodmus lecontei* inhabiting moribund wood of *Myrica cerifera*, 12 Nov 2014, Hulcr 6860 (GenBank KR119074, KR119077, KR119080); Hulcr 6855 (GenBank KR119073, KR119076, KR119079); extracted from preoral mycangia of *A. lecontei* inhabiting moribund wood of *Myrica cerifera*, 1 May 2015, Hulcr 7324 (GenBank KR871005); from fungal garden of *A. minor* in *Platanus occidentalis*, 30 Apr 2015, Hulcr 7346 (GenBank KR871006); extracted from preoral mycangia of *A. rubricollis* inhabiting moribund wood of *Liquidambar styraciflua*, 1 May 2015, Hulcr 7353 (GenBank KR871007); Hulcr 7354 (GenBank KR871008); from fungal garden of *A. rubricollis* in *Liquidambar styraciflua*, 1 May 2015, Hulcr 7373 (GenBank KR871009).

Discussion

Li et al. (2015) described the hyphal system of *Flavodon ambrosius* as dimitic based on hyphal size variation, leading to the assumption that narrow hyphae represented generative mycelial tissue and wider hyphae represented skeletal mycelial tissue. However, true thick-walled skeletal hyphae were not observed by Li et al. (2015) nor in this study, and our observations of arthroconidial production from both hyphal size classes would classify the mycelium of *F. ambrosius* as generative and therefore monomitic. With the description of "*F. cervinogilvus*" (Corner 1987), *Flavodon* was opened to the inclusion of monomitic taxa (although Ryvarden (1973) placed *Polyporus cervinogilvus* in *Oxyporus*). Another monomitic species previously placed in *Oxyporus* is *Emmia latemarginata* (Durieu & Mont.) Zmitr. et al. (Zmitrovich et al. 2006), which also produces arthroconidia (Stalpers 1978). Molecular phylogenies of nuclear ITS and 28S rDNA (Zmitrovich & Malysheva 2014) place *E. latemarginata* in a monophyly with *F. flavus*, although inclusion of this taxon in our 28S rDNA data set led to its placement in a polytomy with *F. flavus* and *I. lacteus*, with *F. flavus* on the shortest branch from the node (data not shown). *Emmia* Zmitr. et al. was described to accommodate *Polyporus latemarginatus* Durieu & Mont. [≡ *Oxyporus latemarginatus* (Durieu & Mont.) Donk (Donk 1966)] based primarily on its phylogenetic distance from other *Oxyporus* species, but we

Figure 1. *Flavodon ambrosius* on PDA medium grown at 25 °C (micrographs taken with phase contrast optics unless otherwise noted): A. cottony, white aerial mycelia above hyaline mycelia in agar radiating from inoculum plug at center of Petri dish (100 mm in diameter); B. dominant type of arthroconidia (<5 µm in diameter), produced from fragmentation of small hyphae; C. small hyphae extending laterally from large, supporting hyphae with simple septum (arrowhead) lacking clamp connection; D. chain of larger arthroconidia (>5 µm in diameter) produced from fragmentation of larger, supportive hyphae.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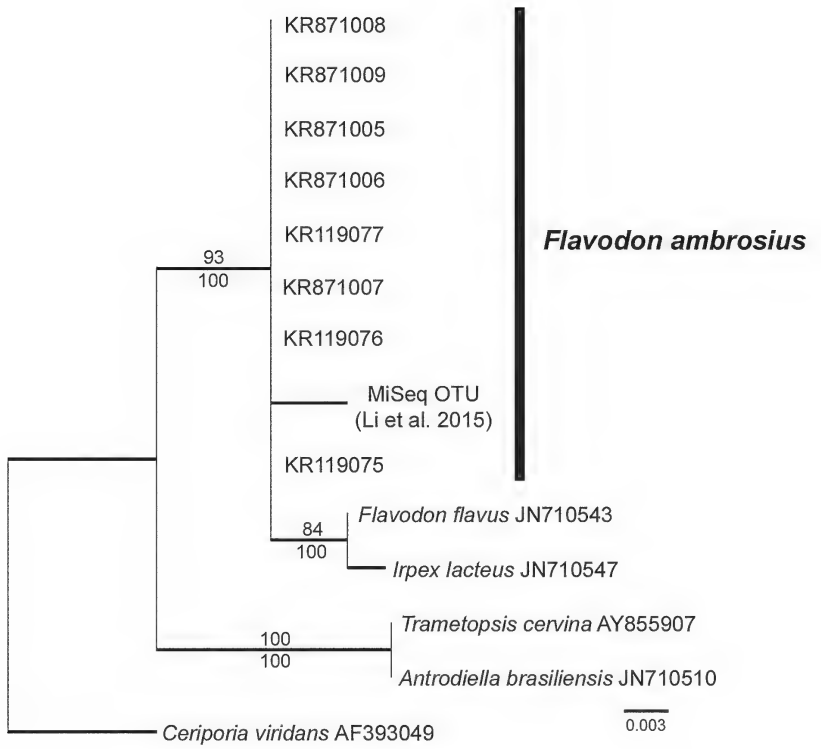

FIGURE 2. Best ML tree from GARLI analysis of 28S rDNA dataset of *Flavodon* and associated taxa, with binomials and GenBank accession numbers; trees from analyses were rooted with *Ceriporia viridans* sequence data. Values above branches represent ML bootstrap percentages >70% for that node from a summary of 100 replicates, and values below branches represent BPP for that node.

believe this species, along with the arthroconidia-producing *F. ambrosius*, is more appropriately placed in the molecularly defined, morphologically diverse *Flavodon*, which has priority over *Emmia*. For these reasons we describe our new taxon, *F. ambrosius*, in *Flavodon*, as suggested by Li et al. (2015).

Our 28S rDNA phylogeny (FIG. 2) places *Flavodon ambrosius* in a paraphyletic group with *F. flavus*. In their phylogenetic analysis of *Polyporales,* which included data from ribosomal and protein-coding DNA, Miettinen et al. (2012) placed *Flavodon flavus* in a lineage with *Irpex lacteus.* The authors contended that their evidence supported the separation of *I. lacteus* and

certain morphologically similar taxa, but they did not specifically address *F. flavus*. Indeed, their morphological generalization of *I. lacteus* (i.e., hymenium irregularly poroid when young and lacking clamp connections at septa) was very similar to that of *F. flavus*. However, the nuclear ITS rDNA sequences obtained from *F. ambrosius* better match *F. flavus* (90–91%) over *I. lacteus* (~88%) as both are presented by Miettinen et al. (2012). Therefore, we are confident in our placement of this new species in *Flavodon* until such time that more evidence justifies its reclassification within a different genus, either described or new.

Li et al. (2015) used Illumina MiSeq® culture-independent sequencing of 28S rDNA to assess the fungal community in *Ambrosiodmus minor* mycangia, while fungal isolations were made at the same locality and time. Li et al. (2015) found a single dominant operational taxonomic unit (OTU) comprising 94% of the resulting sequence reads after the removal of non-fungal and low frequency (<1%) reads. A BLAST query of the dominant OTU in GenBank produced 26 accessions with 99% identity similarity, indicative of the difficulty in differentiating polyporalean taxa using universal molecular markers (Binder et al. 2013). In particular, two *Flavodon flavus* accessions, including JN710543 (Miettinen et al. 2012) used by Li et al. (2015) for phylogenetic analyses, were among this set of 99% similar taxa. We included the MiSeq OTU in our phylogeny (Fig. 2), and it was placed in a polytomy with all other *F. ambrosius* isolates, even though it was on a longer branch, reflecting two polymorphic nucleotides. We conclude that the cultured *F. ambrosius* isolates from the fungus gardens in wood as well as from *Ambrosiodmus* mycangia represent the same species as the dominant OTU in *A. minor* mycangia detected by community meta-barcoding.

The variation of hyphal diameter between the mycangial fungi observed by Li et al. (2015) in *Ambrosiodmus lecontei* and cultured *F. ambrosius* may be explained by differing nutrient sources (the limited habitats selected by the beetle vs. the rich PDA medium) and by desiccation and processing during the fixation of the beetle heads for histological observations. Pure *F. ambrosius* cultures produced aerial hyphae, from which the arthroconidia were derived, that have similar dimensions to the fragmented reproductive propagules ("oidia") described by Tagaki (1967) from *A. rubricollis* galleries. Whether Tagaki observed *F. ambrosius* associated with native *A. rubricollis* remains a topic of investigation, and molecular analyses of pure fungal cultures from Japanese *A. rubricollis* individuals and galleries could indicate an international dispersal of *F. ambrosius*.

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Atrosynnema, a new hyphomycete from dead branches in China

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Abstract — *Atrosynnema digitosporum* gen. & sp. nov., collected on dead branches in Hainan Province, China, is described and illustrated. It has black synnematous conidiomata, integrated unbranched conidiophores, and monoblastic conidiogenous cells that produce brown, obclavate, dictyoseptate, rostrate conidia often with a mucilaginous cap around the apex.

Key words — conidial fungi, taxonomy

Introduction

Many new genera or species of saprobic darkly pigmented hyphomycetes continue to be discovered (e.g., Castañeda Ruíz et al. 2009, 2012, Cruz et al. 2012, Ma et al. 2014, Xia et al. 2014a,b). Hainan Province is considered an important reservoir of biodiversity, but its mycobiota is poorly known. We collected a fungus from dead branches that showed clear differences from all previously described asexual genera and is therefore described herein as a new genus (Ellis 1971, 1976; Subramanian 1971; Matsushima 1975, 1983, 1985, 1989, 1993, 1995; Carmichael et al. 1980; Castañeda-Ruiz 1986; Castañeda-Ruiz & Kendrick 1990a, b, 1991; Wu & Zhuang 2005; Seifert et al. 2011).

Samples were processed, examined and photographed following the methods described in Xia et al. (2014a). Adobe Photoshop 7.0 was used to process photographs into compound images and to modify backgrounds for esthetic reasons. Attempts were made to culture the species from single spores, but they did not germinate. Specimens are deposited in the Herbarium of the Department of Plant Pathology, Shandong Agricultural University, Taian,

China (HSAUP), and Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Atrosynnema J.W. Xia, X.G. Zhang & Z. Li, **gen. nov.**

MycoBank MB 816966

Differs from *Dictyospiropes* by synnematous conidiomata and monoblastic conidiogenous cells.

Type Species: *Atrosynnema digitosporum* J.W. Xia et al.

Etymology: *atro-* black, dark color; *-synnema* referring to the synnematous conidiomata.

Asexual fungus. Colonies on the natural substrate effuse, brown. Mycelium immersed and superficial, of branched, septate, brown, smooth hyphae. Conidiomata synnematous, unbranched, erect, with black stipes. Conidiophores integrated, erect, unbranched, septate, black. Conidiogenous cells monoblastic, integrated, black. Conidial secession schizolytic, with broad scars. Conidia solitary, dry, brown, smooth, dictyoseptate, obclavate, rostrate.

Atrosynnema digitosporum J.W. Xia, X.G. Zhang & Z. Li, **sp. nov.** Fig. 1

MycoBank MB 816967

Differs from *Dictyospiropes ziziphi* by synnematous conidiomata and monoblastic conidiogenous cells, producing smaller conidia with apexes often surrounded by a globose mucilaginous cap.

Type: China, Hainan Province: Wuzhishan, dead branches of unidentified broadleaf tree, 22 Apr. 2015, J.W. Xia (**Holotype**, HSAUP H6651; **isotype**, HMAS 245596).

Etymology: *digito-* finger-like rows or branches;, *-sporum* referring to the conidia.

Colonies on the natural substrate effuse, brown. Mycelium immersed and superficial, of branched, septate, brown, smooth, 2–4 µm wide hyphae. Conidiomata synnematous, unbranched, erect, black, up to 350 µm long, up to 65 µm wide in the broadest part. Conidiophores integrated, erect, unbranched, septate, black, 6–10 µm wide. Conidiogenous cells monoblastic, cylindrical, integrated, black. Conidial secession schizolytic. Conidia solitary, dry, brown, smooth, dictyoseptate, obclavate, rostrate, 65–80 × 12–15.5 µm, apex often surrounded by a globose mucilaginous tunica.

Comments – *Atrosynnema* resembles *Dictyospiropes* M.B. Ellis, but *Dictyospiropes* species have individual, polyblastic conidiogenous cells that produce obclavate, dictyosporous conidia without mucilaginous apexes (Ellis 1976).

In conidial shape, *A. digitosporum* is most similar to *Dictyospiropes ziziphi* M.B. Ellis, but the conidia of *D. ziziphi* are larger, up to 140 µm long and 23 µm wide in the broadest part (Ellis 1976).

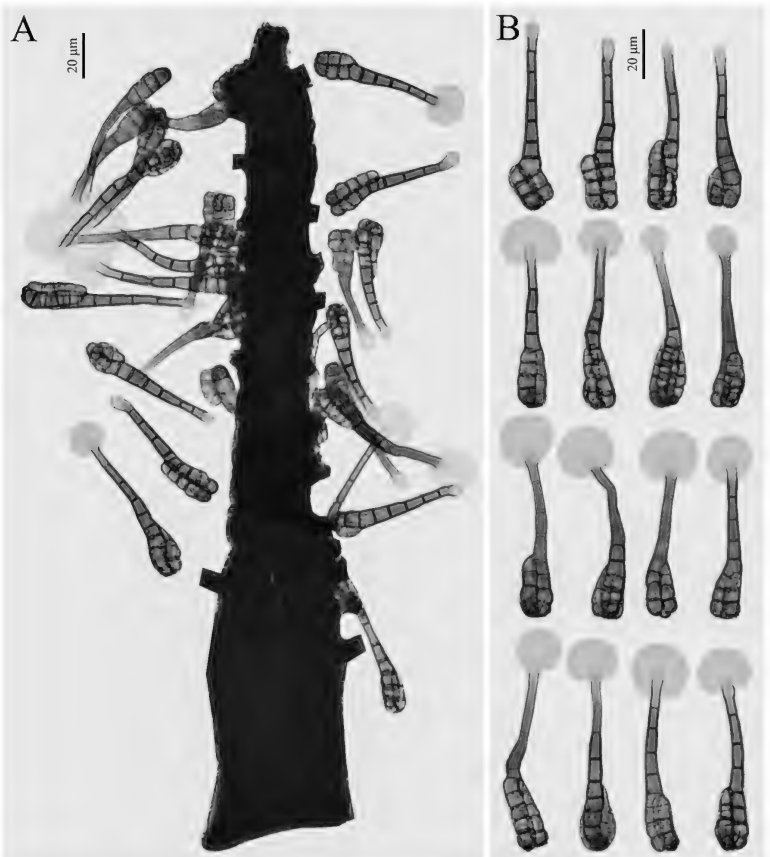

FIG. 1. *Atrosynnema digitosporum.* (ex holotype, HSAUP H6651): A. synnema, conidiophores, conidiogenous cells, and conidia; B. conidia.

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Two new species of *Bactrodesmium* and *Dictyoaquaphila* from Mexico

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Abstract—*Bactrodesmium simile* sp. nov. and *Dictyoaquaphila unisetulata* sp. nov., collected on decaying plant material, are described and illustrated. *Bactrodesmium simile* is distinguished by broadly pyriform, obovoid to globose or somewhat turbinate, 1-septate, golden brown conidia. *Dictyoaquaphila unisetulata* is characterized by ellipsoidal or subglobose, pale gray-brown or pale olivaceous brown separating cells and solitary acrogenous, fusiform, broad fusiform or navicular, dictyoseptate, dark brown conidia, with a cellular, filiform, hyaline apical appendage.

Key words—asexual fungi, systematics, tropical fungi

Introduction

Saprobic dematiaceous hyphomycetes are highly diverse on plant material in tropical forests, where many new genera and species have recently been discovered (e.g., Castañeda-Ruiz et al. 2009, 2012; Heredia et al. 2013, 2014; Zhang et al. 2009, 2011). During a mycological survey of fungi associated with decaying plant materials in a Mexican cloud forest, two interesting dematiaceous hyphomycetes were collected and showed remarkable differences from all previously described *Bactrodesmium* and *Dictyoaquaphila* species. These two fungi are therefore described here as new to science.

Materials & methods

Samples of litter were placed in paper and plastic bags, taken to the laboratory, and prepared according to Castañeda-Ruiz (2005). Mounts were prepared in PVL (polyvinyl alcohol and lactic acid) and measurements were made at a magnification of ×1000. Micrographs were obtained with a Nikon Eclipse 80i microscope equipped with bright field and Nomarski interference optics. The type specimens are deposited in the Herbarium of Instituto de Ecología A.C., Xalapa, Veracruz, Mexico (XAL).

Taxonomy

Bactrodesmium simile R.M. Arias, Heredia & R.F. Castañeda, **sp. nov.** Fig. 1a, b

MycoBank MB 808325

Differs from *Bactrodesmium novae-geronense* by its bigger conidia.

Type: Mexico, Veracruz State, Xalapa city, Parque Francisco Javier Clavijero, 19°30′N ″96°56′W, on decaying twigs, 12 September 2011, coll. R.M. Arias (**Holotype**, XAL CB1689).

Etymology: Latin, *simile*, referring to its similarity to *Bactrodesmium novae-geronense*.

Conidiomata on the natural substrate, sporodochial, scattered, pulvinate or punctiform, golden olivaceous-brown. Mycelium superficial and immersed composed of septate, branched, subhyaline to very pale brown, smooth hyphae, 1–3.5 µm diam hyphae. Conidiophores undifferentiated, mostly reduced to conidiogenous cells. Conidiogenous cells monoblastic, integrated or discrete, determinate, cylindrical, straight or prostrate, very pale brown, 12.5–29 × 2–5 µm. Conidial secession rhexolytic. Conidia solitary, acrogenous, broadly pyriform, obovoid to globose or somewhat turbinate, 1-septate, smooth, golden brown to pale olivaceous-brown, 19–24 × 12–16 µm, asymmetrical, with a cuneiform, 7.5–11 × 5–8.5 µm basal cell, and a hemispherical, 12–16 ×12–16 µm apical cell, with markedly guttulate, dark cell lumina.

Additional specimen examined: **MEXICO**, **Veracruz State**, **Acatlán**, Volcán de Acatlán, 19°40′N 96°51′W, on decaying twigs, 28 September 2011, coll. R.M. Arias (XAL CB1690).

Note: Forty-four species have been accepted in *Bactrodesmium* (Hernández-Restrepo et al. 2013); only *B. novae-geronense* R.F. Castañeda is similar to *B. simile*, from which it differs by its smaller conidia (8–13 × 7–10 µm Castañeda-Ruiz, 1985).

Dictyoaquaphila unisetulata R.M. Arias, Heredia & R.F. Castañeda, **sp. nov.**

MycoBank MB 808327 Fig. 1c–e

Differs from *Dictyoaquaphila appendiculata* by its broad fusiform to navicular conidia, with a smaller cellular, filiform apical appendage.

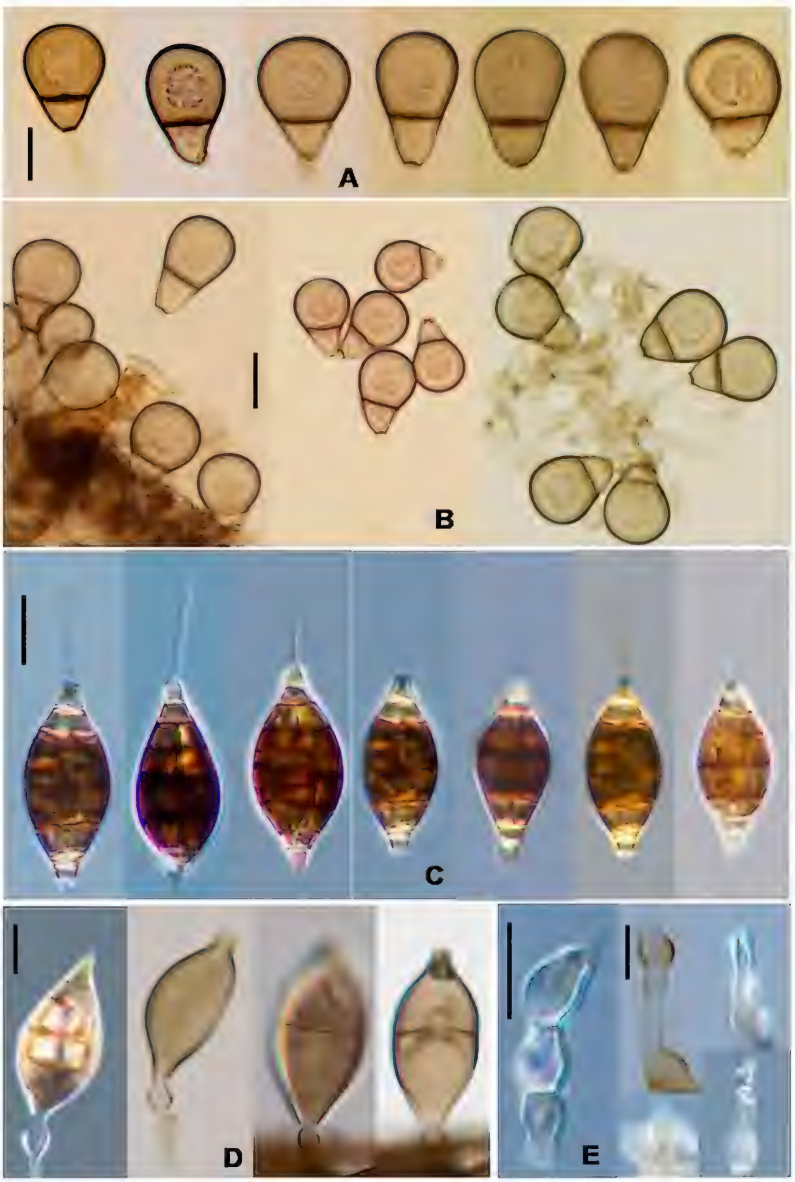

Fig. 1. ***Bactrodesmium simile*** (ex holotype, XAL CB1689, XAL CB1690): A. conidia; B. conidiogenous cell and conidia. ***Dictyoaquaphila unisetulata*** (ex holotype, XAL CB1688): C. conidia; D. separating cells and conidia; E. conidiophores, conidiogenous cells, and separating cell. Scale bars: A, C–E = 10 µm; B = 15 µm.

Type: Mexico, Veracruz State, Soteapan city, Volcano Santa Marta, 18°20′N 94°53′W, on rotten wood, 6 August 2011, coll. G. Heredia (**Holotype**, XAL CB1688).

Etymology: Latin, *uni-*, meaning one, + *-setulata*, referring to the apical appendage.

Colonies on the natural substrate effuse, granulose, dark brown to black. Mycelium immersed, composed of septate, slightly branched, pale brown, smooth, hyphae, 1–2 µm diam. Conidiophores distinct, single, erect or prostrate, straight or slightly sinuate, 1–2-septate, pale brown, smooth, 15–30 × 3–5 µm, occasionally reduced to conidiogenous cells. Conidiogenous cells mono- and polyblastic, cylindrical, sometimes inflated, integrated or discrete, determinate, smooth, brown to pale brown, 4–7 × 2–4 µm. Separating cells ellipsoidal or subglobose, pale gray-brown or pale olivaceous-brown, smooth, 6–8 × 3–5 µm. Conidial secession schizolytic. Conidia solitary, acrogenous, dictyoseptate, euseptate, broad fusiform, navicular, subcylindrical-truncate basal cell and obtuse or rounded apical cell, 26–30 × 12.5–16 µm, variegated, dark brown at the middle cells, brown to pale brown near the end cells and subhyaline or pale brown at the end cells, smooth, with a cellular, filiform, hyaline, apical appendage, 6–19 µm long.

Note: Monteiro et al. (2016) established the genus *Dictyoaquaphila* typified by *D. appendiculata* Monteiro et al. The genus is characterized by mono- and polyblastic, cylindrical, integrated or discrete, terminal, determinate or sympodial elongated conidiogenous cells, with swollen, fusiform, ellipsoidal or shortly clavate, brown or dark brown separating cells. The conidia are solitary, acrogenous, euseptate, dictyoseptate, fusiform to obclavate, brown to dark brown and paler at the ends, with several divergent, filiform or narrow cylindrical, hyaline appendages at the ends. *Dictyoaquaphila appendiculata* differs from *D. unisetulata* by its conidia being broad ellipsoid-fusiform to prolate subglobose, 37–45 × 17–27 µm, with 0–3 divergent, filiform or narrow cylindrical, hyaline apical appendages, 20–42 × 1–1.5 µm and sometimes 0–2 (–3) divergent, filiform or narrow cylindrical, hyaline basal appendages, 20–35 × 1–1.5 µm (Monteiro et al. 2016).

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Linkosia aquatica sp. nov. from submerged plant debris from Brazil

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Abstract — A new species, *Linkosia aquatica*, found on a submerged decaying twig in a stream, is described and illustrated. It is characterized by cylindrical, slightly clavate, sometimes filiform conidia that are 8–21-septate with a distinctly subclavate pale brown apical cell. A key to all *Linkosia* species and illustrations of their conidia are provided.

Key words — hyphomycetes, freshwater, taxonomy

Introduction

Linkosia A. Hern-Gut. & B. Sutton, typified by *L. coccothrinacis* (A. Hern-Gut. & J. Mena) A. Hern-Gut. & B. Sutton, is distinguished by conidiophores reduced to a monoblastic, lageniform, subulate to subcylindrical, determinate conidiogenous cell and solitary, obclavate to cylindrical or clavate, sometimes rostrate, distoseptate, pale brown or brown conidia (Hernández-Gutiérrez & Sutton 1997). Since the genus was established, ten additional *Linkosia* species have been either described as new or transferred from *Sporidesmium* and *Janetia* (Almeida et al. 2014, Castañeda-Ruiz et al. 2000, Delgado 2014, Ma et al. 2011, Wu & Zhuang 2005, Zhang et al. 2009).

During research on hyphomycetes occurring on submerged decaying plant debris, a unique specimen of *Linkosia* was found, which is described here as new. A key to the eleven accepted *Linkosia* species is presented, based on their conidial morphology.

Materials & methods

Samples of submerged plant materials in freshwater from Serra da Fumaça, Bahia, Brazil, were placed in plastic bags. The materials were washed in tap water and placed on moist filter paper in glass Petri dishes (100 mm diam.). The dishes were then placed in coolers (150 L capacity), filled with 200 mL sterile water and 2 mL glycerol, and incubated at room temperature (Castañeda-Ruiz et al. 2016). The plant material was examined at regular intervals over a month of incubation for the presence of microfungi. Mounts were prepared in PVL (polyvinyl alcohol and lactic acid) and measurements were taken at ×1000. Microphotographs were made using a BX51 Olympus microscope equipped with bright field and Nomarski interference optics and a DP25 Olympus digital camera. The specimens were deposited in the Herbarium of Universidade Estadual de Feira de Santana, Bahia, Brazil (HUEFS).

Taxonomy

Linkosia aquatica L.B. Conc., M.F.O. Marques & R.F. Castañeda **sp. nov.** Fig 1

MycoBank MB 815293

Differs from *Linkosia multisepta* by its cylindrical, slightly clavate, sometimes filiform, mostly 8–21-septate, straight conidia.

Type: Brazil, Bahia State: Pindobaçu, Serra da Fumaça, Riancho das Neves, 10°74′S 40°36′W, on submerged decaying twig of an unidentified plant in a stream, 7.XII.2014; coll. L.B. Conceição (**Holotype**: HUEFS 216022).

Etymology: Latin, *aquatica*, refers to its growing in water.

Colonies on the natural substrate effuse, hairy, brown. Mycelium mostly superficial. Hyphae slightly branched, smooth, pale brown to black, 2–4 µm wide. Conidiophores absent. Conidiogenous cells monoblastic, determinate, lageniform, subulate to subcylindrical, dark brown or black, smooth, 12–18 × 5–6 µm. Conidial secession schizolytic. Conidia solitary, acrogenous, straight, cylindrical, slightly clavate, sometimes filiform, conical truncate at the basal cell, slightly inflated at the apical cell, 8–21-distoseptate, smooth, dry, versicolored with the basal cells brown to dark brown, the middle cells brown, and cells toward the apex pale brown; overall 50–240(–330) × 4–5 µm with a 4–5 µm long basal cell and 10–13 × 4–5 µm apical cell.

Note: *Linkosia aquatica* is superficially similar to *L. multisepta* W.P. Wu, which differs by its conidia that are obclavate to obclavate-rostrate, 27–30-distoseptate, straight or slightly curved, pale brown to brown, and 300–380 × 12–14 µm (Wu & Zhuang 2005, as "*multiseptum*").

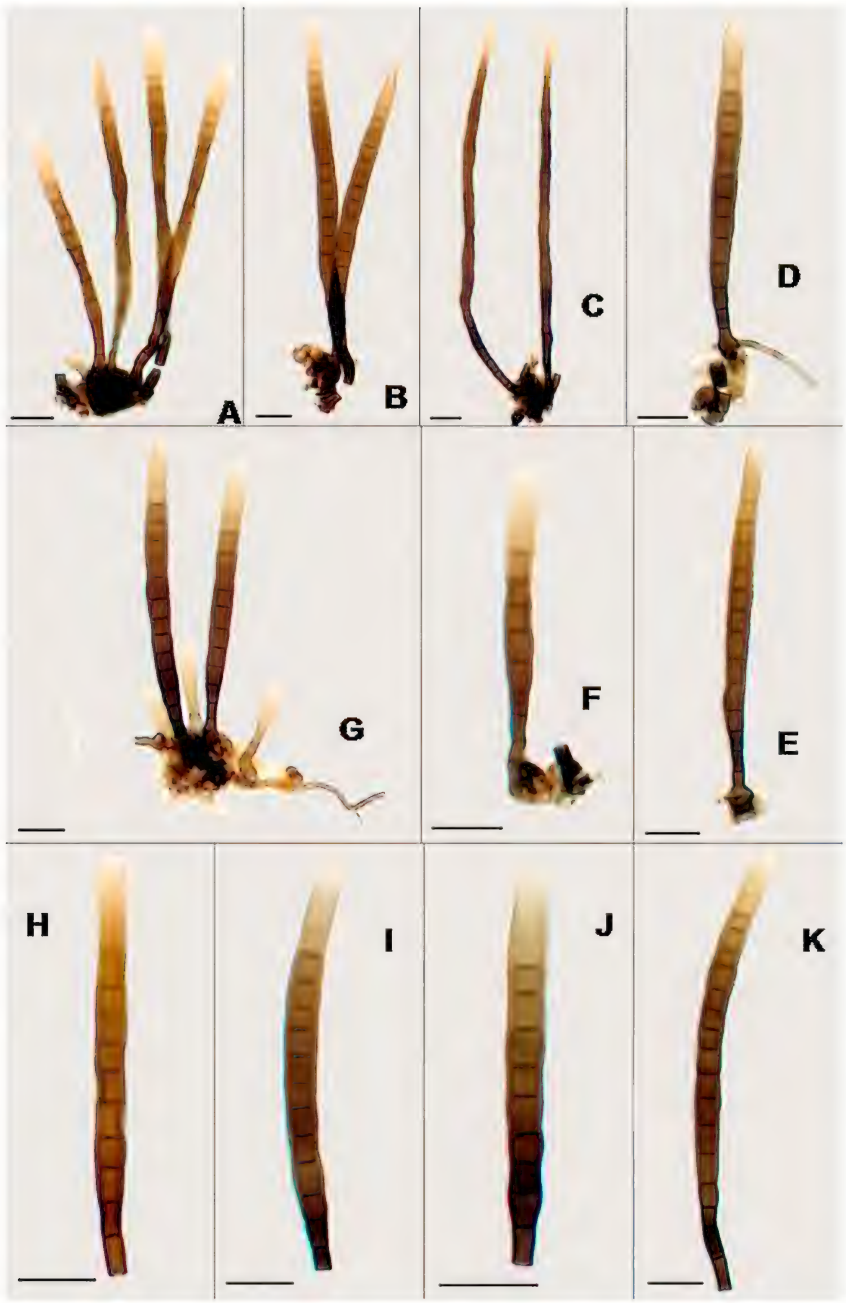

Fig. 1. *Linkosia aquatica* (holotype, HUEFS 216022): A–G. conidiogenous cells and conidia; H–K. conidia. Scale bars = 10 µm.

Key to *Linkosia* species (Figs. 1–4)

1. Conidia with an apical appendage, navicular, 5–6-distoseptate, 28–42 × 9–13 µm (appendage excluded), appendage 5–12 µm long ..... *L. ponapensis*
1. Conidia without apical appendage 2

2. Conidia rostrate 3
2. Conidia not rostrate 9

3. Conidia 4–7-distoseptate, narrowly obclavate to obclavate rostrate, 43–71.5 × 7–11 µm ..... *L. coccothrinacis*
3. Conidia not as above 4

4. Conidia <18-septate 5
4. Conidia sometimes >18-distoseptate 6

5. Conidia 12–14-distoseptate, obclavate to obclavate-rostrate, 110–125 × 9–12 µm ..... *L. obclavata*
5. Conidia 9–18-distoseptate, narrowly obclavate to long obclavate rostrate, (73–)91–158(–172) × 6.5–12 µm ..... *L. longirostrata*

6. Conidia sometimes >20-distoseptate 7
6. Conidia 15–20-distoseptate, obclavate to obclavate-rostrate, 100–160 × 13–15 µm ..... *L. fusiformis*

7. Conidia <25-distoseptate 8
7. Conidia 27–30-distoseptate, obclavate to obclavate-rostrate, 300–380 × 12–14 µm ..... *L. multisepta*

8 Conidia 15–21-distoseptate, obclavate to obclavate-rostrate, 122–177 × 12–16 µm ..... *L. mori*
8. Conidia 16–21-distoseptate, obclavate to obclavate-rostrate, 160–210 × 7.5–9.5 µm ..... *L. hibisci*

9. Conidia smooth 10
9. Conidia verruculose 11

10. Conidia bacilliform, attenuated at the ends, 5–9-distoseptate, 60–156 × 5–8 µm ..... *L. bacilliformis*
10. Conidia cylindrical, slightly clavate, sometimes filiform, 16–21-distoseptate, 50–240(–330) × 4–5 µm ..... *L. aquatica*

11. Conidia pyriform or obpyriform to cylindrical 1–7-distoseptate, 16–57 × 5.5–9 µm ..... *L. canescens*
11. Conidia pyriform or obpyriform, 4–6-distoseptate, 31–37 × 7–8 µm .... *L. refugia*

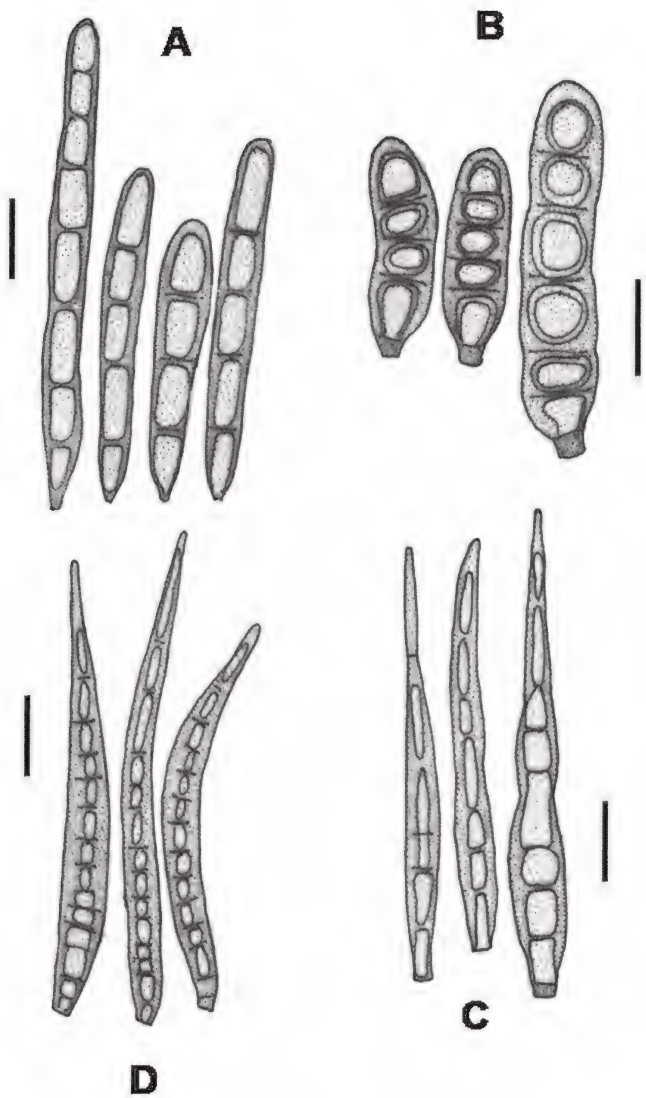

Fig. 2. Conidia of *Linkosia* spp.:
A. *L. bacilliformis* (Gamundi et al. 1979); B. *L. canescens* (Sutton & Pascoe 1988);
C. *L. coccothrinacis* (Hernández-Gutiérrez & Sutton 1997); D. *L. fusiformis* (Wu & Zhuang 2005).
Scale bars = 10 µm.

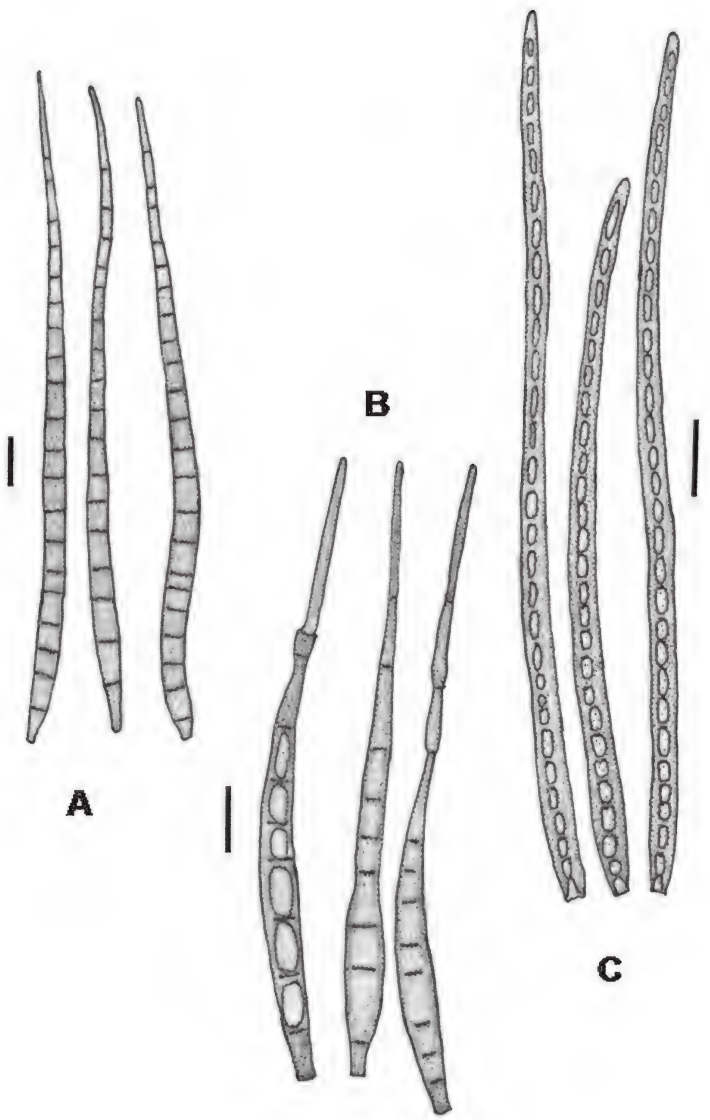

Fig. 3. Conidia of *Linkosia* spp.:
A. *L. hibisci* (Ma et al. 2011); B. *L. longirostrata* (Delgado 2014);
C. *L. multisepta* (Wu & Zhuang 2005).
Scale bars = 10 µm.

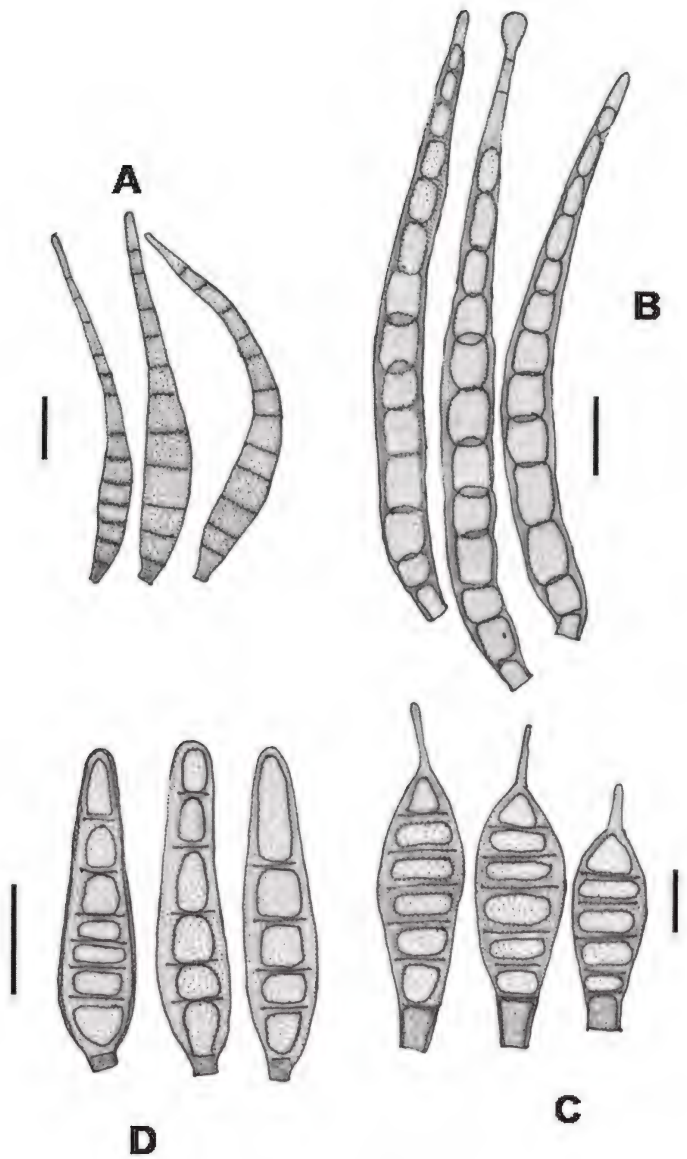

Fig. 4. Conidia of *Linkosia* spp.:
A. *L. mori* (Zhang et al. 2009); B. *L. obclavata* (Wu & Zhuang 2005);
C. *L. ponapensis* (Matsushima 1981); D. *L. refugia* (Sutton & Pascoe 1988).
Scale bars = 10 µm.

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Two new species of *Suillus* associated with larches in China

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Abstract —Two *Suillus* species from China, *S. alpinus* and *S. aurihymenius*, are described as new. Both *S. alpinus*, a subalpine species currently known only from southwestern China, and *S. aurihymenius*, a boreal species from northeast China, are strictly associated with larches and morphologically similar to the European *S. tridentinus* by having a viscid squamulose pileus and veiled stipe. *Suillus alpinus* is distinguished by a much duller basidiome, paler orange pores, a faint bluish discoloration of the context, and a heavily reticulate stipe apex, while *S. aurihymenius* has a reddish gold hymenium, a context that discolors a deep reddish brown, and a less squamulose pileus. The identities of the two new species and their affinity with *S. tridentinus* are supported by ITS-rDNA sequence analyses. *Suillus tridentinus*, *S. alpinus*, and *S. aurihymenius* form a monophyletic clade representing a morphologically similar European-Asian temperate lineage associated with *Larix*.

Key words — *Basidiomycota*, ectomycorrhizal fungi, phylogeny, *Suillaceae*, taxonomy

Introduction

Suillus Gray (*Suillaceae*, *Boletales*, *Basidiomycota*) comprises ectomycorrhizal fungi (EcM) associated almost exclusively with *Pinaceae* and with a host-dependent distribution (Kretzer et al. 1996; Singer 1945; Smith & Thiers 1964, 1971; Thiers 1975). The genus is ideal for studying EcM fungal phylogeny and biogeography as well as coevolution between EcM fungi and host plants (Kretzer et al. 1996, Manian et al. 2001, Mueller et al. 2001, Wu et al. 2000). Except for

a few reports, it is known that *Suillus* species mostly grow with *Pinus*, *Larix*, and *Pseudotsuga* (Alan et al. 2000; Kretzer et al. 1996; Philips 2005; Smith & Thiers 1964, 1971). Engel et al. (1996), who analyzed *Suillus* species worldwide, found that only about ten (around 5% of the described species) were symbiotic with larches. *Suillus* species associated with larches are key to understanding the diversity of the whole genus and for investigating potential coevolution between *Suillus* and theirs hosts (Kretzer et al. 1996). *Suillus* species associated with *Larix* form basal clades in the genus, suggesting that *Larix* represents an ancestral host for *Suillus* (Kretzer et al. 1996, Wu et al. 2000).

China has rather high *Larix* diversity, ranging in distribution from boreal forests in the north to subalpine regions in the south. Among 15 species of *Larix* in the world, 11 species (4 endemic, 2 introduced) are known from China (Fu et al. 1999). Some *Suillus* species associated with *Larix* have been investigated taxonomically and/or biogeographically in China. Wu et al. (2000) and Mueller et al. (2001), who explored phylogeographic relationships between North American and East Asian *Suillus* species, confirmed *S. asiaticus* and *S. cavipes* in north China. Ding & Wen (2003) enumerated 36 *Suillus* species from China, of which eight were associated with *Larix*. Our survey, which confirmed some of those species in China's larch forests, also revealed two new species that help explain *Suillus* species diversity in China and provide additional taxa for understanding the phylogeny of *Suillus* as a whole.

Materials & methods

Macro- and micro-morphological descriptions were based on fresh and dried materials respectively. Color codes follow Kornerup & Wanscher (1961). For micromorpological observations, materials were revived in 5% KOH solution for several seconds and then dyed with Congo red (aqueous reagent). Pileipellis preparations followed Wang & Verbeken (2006). Micro-morphological features were examined under a Nikon E400 microscope (1000×) and drawings were made using an installed Y-IDT drawing tube. Basidiospore observation and documentation follow Yang (2000). All specimens examined were deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS).

Total DNA was extracted from silica-dried material using a modified CTAB procedure (Doyle & Doyle 1987). The polymerase chain reaction (PCR) was performed using primer pairs ITS5/ITS4 to amplify the internal transcribed spacer (ITS) region of the nuclear ribosomal DNA (White et al. 1990). Both strands were sequenced on an ABI 3730 DNA analyzer with an ABI BigDye 3.1 terminator cycle sequencing kit (Shanghai Sangon Biological Engineering Technology & Services Co., Ltd, Shanghai). Sequences JN201972–201976 have been submitted to GenBank. We retrieved ITS sequences of all *Suillus* species associated with *Larix* from GenBank and selected 15 most representative sequences for further phylogenetic analysis (Fig. 4). DNA sequences were aligned with

BioEdit and Clustal X with manual adjustments. *Rhizopogon subcaerulescens* A.H. Sm. and *Truncocolumella citrina* Zeller, representing the genera closest to *Suillus* (Bruns & Palmer 1989), were selected as outgroup. Phylogenetic relationships were analyzed with Maximum Parsimony (MP) using PAUP v4.0 (Swofford 2003) and with Bayesian analyses using MrBayes version 3.1.2 (Ronquist & Huelsenbeck 2003). Bayesian analyses were set with default priors, run with 4 chains for 2,000,000 generations and sampled every 100 generations.

Taxonomy

Suillus alpinus X.F. Shi & P.G. Liu, **sp. nov.** Fig. 1, 2a

MycoBank MB 816992

Differs from *Suillus tridentinus* by its association with *Larix potaninii* in southwest China, and by its duller basidiomata, less orange colored pores, faint bluish context discoloration, and heavily reticulate stipe apex.

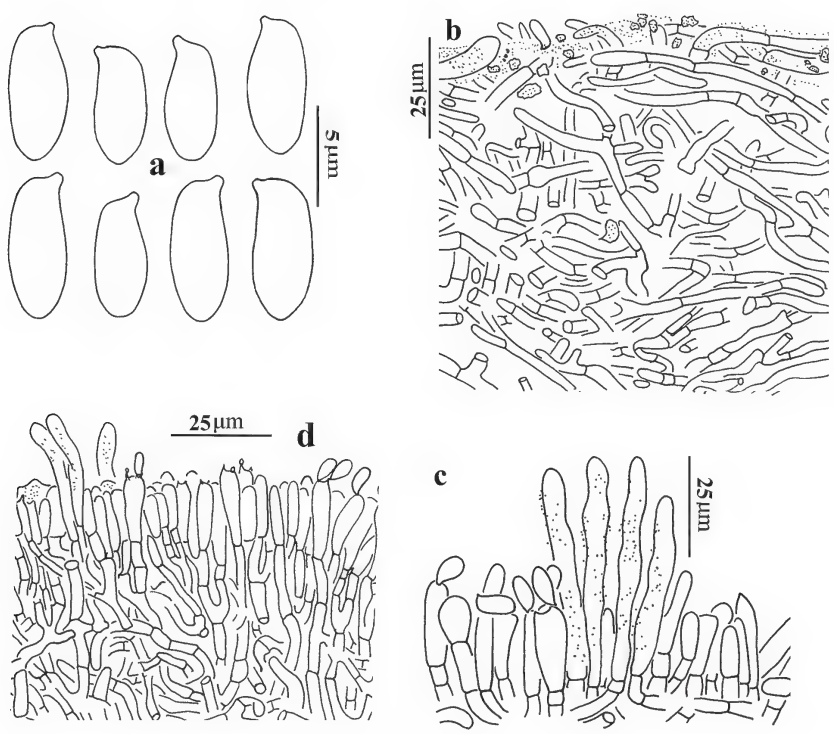

Fig 1. *Suillus alpinus* (holotype).
a. basidiospores. b. pileipellis. c. pleurocystidia. d. hymenium.

Type: China, Yunnan Prov., Shangri-La, 27°49′N 99°43′E, alt. 3600 m, scattered to gregarious under *Larix potaninii*, 16 September 2010, Shi697 (**Holotype**, HKAS 63128; GenBank, JN201974).

Etymology: *alpinus*, referring to its occurrence in subalpine regions.

Basidiomata medium-sized. Pileus 4–6.5 cm diam., convex at maturity; surface viscid, yellowish brown to pale reddish gray-brown (5D5-6E4), with grayish fibrillose squamules beneath the glutinous layer, with appendicules white to brown along margin. Stipe 40–70 × 8–15 mm, subcylindrical, equal or clavate, solid; bright yellow at apex, downwards gray brown to more reddish (6C4-6D3), white at the base; annulus well developed and persistent, superior; reticulate above the annulus; lacking glandular dots. Context 6–11 mm thick halfway to the margin in pileus, dull white, slowly turning blue or faint blue in the stipe and near the tubes when cut. Tubes 4–7 mm deep, pale dingy yellow (lighter than 4B3), becoming dingy yellowish olive (lighter than 3B3) when bruised, decurrent to stipe. Pores small, 1 per mm^2, pale dingy yellow, or concolorous with the tubes, slowly turning dingy blue when injured or in age. Odor indistinctive. Taste mild.

Basidiospores (80/3/4)10–12(–13.5) × 4–5 μm, Q = 2.20–2.80, Q_m = 2.57 ± 0.1, elongate ellipsoid, yellowish to olive-brown in 5% KOH solution, thin-walled. Basidia 22–37 × 7–9 μm, clavate, with 2–4 sterigmata. Pleurocystidia scattered, 55–73 × 8–12 μm, narrowly clavate or cylindrical; content hyaline in 5% KOH, with brownish incrustations. Cheilocystidia numerous, similar to pleurocystidia. Hymenophoral trama composed of gelatinous hyphae, slightly divergent; hyphae 4–8 μm in diameter, thin walled. Pileipellis an ixotrichoderm; hyphae 4–10 μm in diameter, thin-walled, yellowish in 5% KOH near surface with scattered brownish incrustations.

Ecology & distribution—scattered to gregarious under *Larix potaninii* in subalpine (3300–4500 m) regions of southwestern China, fruiting from May to September. Since no other tree species except *Abies* sp. was observed around the collection areas, *L. potaninii* is regarded as the host, as *Abies* is not normally regarded as a host genus for *Suillus*.

Additional specimens examined — **China**, **Sichuan**: **Derong**, Kunmu Mountain, alt. 4200 m, 20 July 2004, Z.L. Yang 4170 (HKAS 45556); **Yunnan**: **Shangri-La**, Benzilan, Baima Snow Mountains, 28°14′N 99°17′E, alt. 4200 m, 6 September 2009, X.F. Shi261 (HKAS 63133; GenBank, JN201976); Bita Lake, 27°48′N 99°54′E, alt. 3700 m, 12 August 2008, F.Q. Yu 08812004 (HKAS 63342); near Shangri-La Town, 27°49′N 99°42′E, alt. 3300 m, 21 May 2008, F.Q. Yu 08521001 (HKAS 63341).

Comments—*Suillus alpinus* is characterized by the viscid pileus with fibrillose squamules beneath the glutinous layer and veil remnants along the margin, persistent annulus, and bluish context discoloration.

Fig 2. Habit. a. ***Suillus alpinus*** (holotype). b. ***Suillus aurihymenius*** (holotype).

Suillus aurihymenius X.F. Shi & P.G. Liu, **sp. nov.** Fig. 2b, 3

MycoBank MB 817116

Differs from *Suillus tridentinus* by its association with *Larix gmelinii* in northeast China, and by its reddish gold hymenium color, stronger reddish brown discoloration of the context, and less squamulose pileus.

Type: China. Heilongjiang: Greater Khingan Mountains Area, Huzhong Nature Reserve, 51°37′N 123°03′E, alt. 800 m, scattered to gregarious under *Larix gmelinii* (Rupr.) Kuzen., 21 August 2010, Shi597 (**Holotype**, HKAS 63129; GenBank, JN201972);

Etymology: *aurihymenius*, referring to the golden pores.

Basidiomata medium-sized. Pileus 4.4–8 cm in diameter, convex to flat at maturity; surface very glutinous when wet, ochre-yellow to cinnamon-brown or crimson-brown (darker than 7E8) with yellow brown (5E7) fibrils under the glutinous layer; appendicules whitish brown (5D5) along margin; Stipe 40–78 × 7–16 mm, subcylindrical, equal or clavate, solid; bright yellow at apex, reddish brown below or concolorous with the pileus; the membranous whitish-pink veil often leaving an apical annulus when young, nonpersistent; lacking glandular dots; pink mycelium in stipe base. Context 5–6 mm thick, yellowish white, slowly turning to light yellow (4A4) or pale orange (5A3) when cut or bruised. Tubes 5–9 mm deep, orange yellow or light yellow (4A7-4A5), becoming reddish yellow to light orange (5A5) when bruised, decurrent to the stipe. Pores small, 1 per mm^2, angular, compound, concolorous with the tubes. Odor indistinct. Taste mild; edible, as found in the local market.

Basidiospores (80/2/4) (9.5–)10–11.5 (–12) × 4–5 μm, Q = 1.96–2.31, Q_m =2.15 ± 0.18, elongate ellipsoidal, reddish brown or gray brown in 5% KOH solution, thin-walled. Basidia 25–35 × 79.5 μm, clavate, with 2-4 sterigmata. Pleurocystidia abundant, 60–76 × 9–11 μm, narrowly clavate, content hyaline in 5% KOH solution and lacking brownish incrustations. Cheilocystidia similar to pleurocystidia. Hymenophoral Trama gelatinous and divergent; hyphae 4–7 μm in diameter, thin-walled. Pileipellis a very thick layer of interwoven gelatinous hyphae 4–12 μm in diameter, thin-walled.

Ecology & Distribution — scattered to gregarious under Dahurian larch (*Larix gmelinii*) on Greater Khingan Mountain in northeastern China, fruiting during the summer and fall. As this species grows in a monocultural forest, *L. gmelinii* is proposed as the host.

Additional specimens examined — **CHINA, Inner Mongolia: Genhe market**, 25 August 2010, Shi616 (HKAS 63130); **Argun Area**, Mordaga Native Forest Park, 51°19′N 120°40′E, alt. 540 m, scattered to gregarious under *Larix gmelinii* (Rupr.) Kuzen., 26 August 2010, Shi621 (HKAS 63131).

Comments — *S. aurihymenius* and *S. alpinus* look similar in the field, but the pileus of *S. aurihymenius* is more reddish-brown, viscid, and fibrillose or

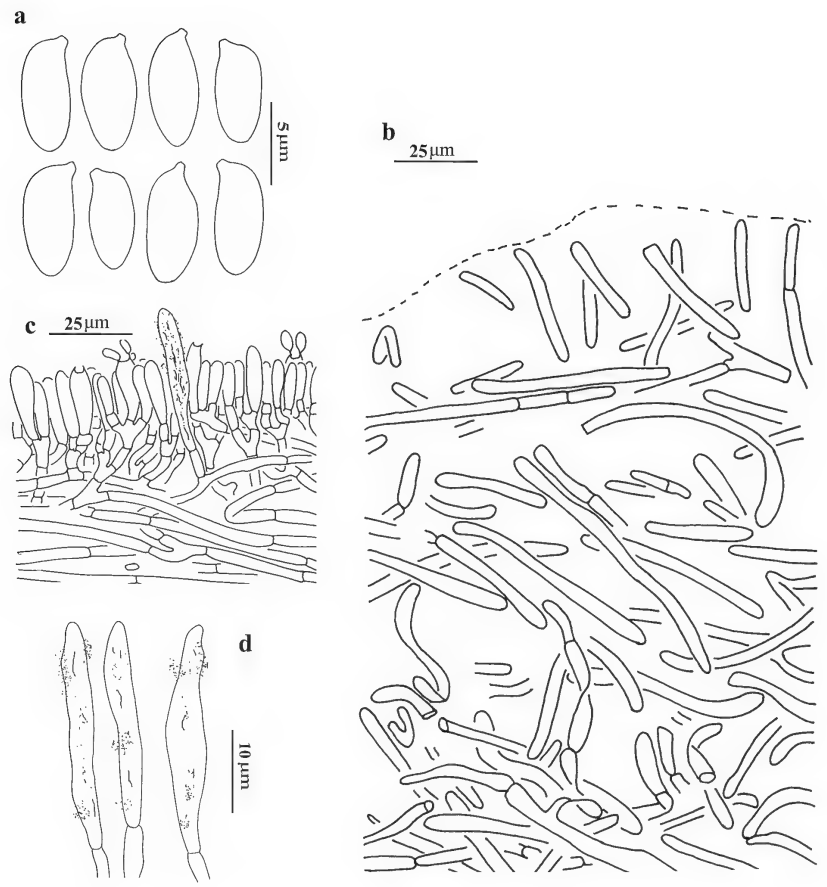

Fig 3. *Suillus aurihymenius* (holotype).
a. basidiospores. b. pileipellis. c. hymenium. d. pleurocystidia.

squamulose than that of *S. alpinus,* and the context of *S. aurihymenius* does not change to blue when bruised.

Phylogenetic results

ITS-rDNA sequences were obtained for *S. alpinus* and *S. aurihymenius.* The molecular dataset consisted of 22 OTUs and 731 characters, of which 31 were ambiguous and excluded from the analyses. Of the remaining 653 characters, 529 characters were constant, 92 were uninformative, and 110 were parsimony-informative. Parsimony analysis produced one most parsimonious tree of 1000

replications with consistency index (CI) = 0.743, retention index (RI) = 0.796, and rescaled consistency index (CI) = 0.257. The tree is shown with bootstrap values (>60%) in Fig. 4. Topology of the Bayesian tree is the same as the MP tree, and posterior probability values are included at each node in Fig. 4. *Suillus alpinus* forms a monophyletic clade with 100% bootstrap and 1.0 posterior probability supports. The *S. aurihymenius* monophyletic clade was supported with 99% bootstrap value and 0.96 posterior probability. Also the two new species and *S. tridentinus* forms a monophyletic clade with 92% bootstrap support and 1.0 posterior probability.

Discussion

Suillus alpinus and *S. aurihymenius* appear similar in the field and are both characterized by a viscid pileus with fibrillose squamules beneath the glutinous layer, veil remnants hanging from the margin, and a veiled stipe lacking any glandular dots. They match the morphological and ecological descriptions of *Suillus* sect. *Larigni* (Singer 1986). Both species also morphologically close to the European *S. tridentinus* (Bres.) Singer. Compared with other *Suillus* species, all three species have very long spores, often exceeding 10 µm (Moser 1983). Kretzer et al. (1996), who investigated the phylogenetic diversity of *Suillus* species associated with *Larix*, identified two well-supported clades excluding *S. spectabilis*. Our analyses strongly support the Asian *S. alpinus* and *S. aurihymenius* in a monophyletic clade with the European *S. tridentinus*. Species in this monophyletic clade can be separated morphologically from *S. grevillei* and other species in its sister clade containing by the presence of squamules beneath the glutinous layer, veil remnants on the pileal margin, and much darker basidiomata.

It is interesting to note that *S. aurihymenius*, which grows in northwestern China, shows a closer affinity to the European *S. tridentinus* than to the southwestern Chinese *S. alpinus* in the phylogenetic tree. This relationship is similar to the situation in *Chroogomphus* (Li et al. 2009), where northern Chinese samples are conspecific with European samples while *Chroogomphus* samples from southwestern China represent a separate sibling species. Phylogenetic and morphological comparisons suggest that *S. aurihymenius* and *S. tridentinus* are sister species. The high genetic similarity between European and northern Chinese taxa might have been facilitated by the dispersal between different populations and thus contributed to the low genetic divergence (Petersen & Hughes 2007). As has been shown in other fungal groups (Ge et al. 2008, Li et al. 2009, Zhang et al. 2004), comparison analyses of counterparts or conspecific species in China's northern and subalpine regions would help elucidate EcM fungal diversification and fill geographic sampling gaps in temperate regions.

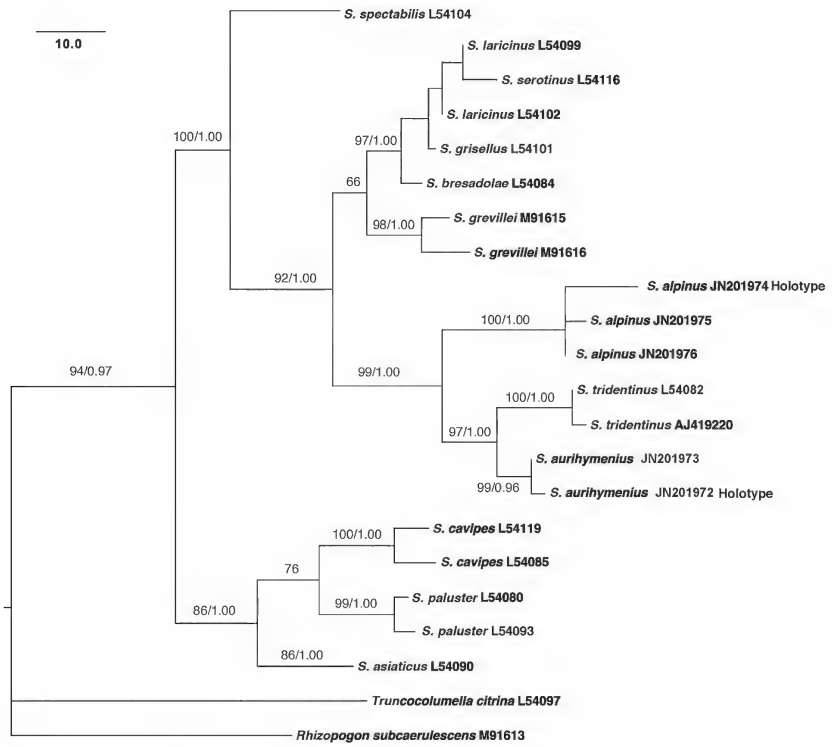

FIG 4. Phylogenetic tree resulting from Maximum Parsimony analysis of partial nuclear subunit ribosomal DNA sequences (ITS) of *Larix*-associated species of *Suillus*. Numbers above branches are bootstrap values >50%. Values after the slash are posterior probability values obtained through Bayesian analysis of the same data set. The sequences *S. alpinus* and *S. aurihymenius* were generated in this study; all other sequences were obtained from Kretzer et al. (1996) except for *S. grevillei* (Baura et al. 1992) and AJ419920 and M91613 (Martín & Raidl 2002).

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First record of *Parasola lilatincta* from Pakistan

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Abstract—*Parasola lilatincta* a lilaceous coprinoid mushroom (*Psathyrellaceae, Agaricales*) is characterized and illustrated from Malakand, Pakistan. Morpho-anatomical description and sequencing of the ITS region of the rDNA are given. This is a new record for Pakistan.

Key words—*Basidiomycota,* phylogeny, plicate pileus, taxonomy

Introduction

Parasola Redhead et al. was introduced when the coprinoid genus *Coprinus* Pers. was divided into four genera: *Coprinopsis* P. Karst., *Coprinellus* P. Karst., *Parasola* and *Coprinus* s.s. (Redhead et al. 2001). *Coprinus* s.s. was retained in *Agaricaceae*, while the other three taxa were placed in the newly validated family *Psathyrellaceae*. *Parasola* species have small and deeply plicate pilei, ranging from yellow-brown to tawny and paler colors. *Parasola* is morphologically separated from the closely related *Coprinellus*, *Coprinopsis* and *Psathyrella* (Fr.) Quél. by the complete absence of a veil structure and the lack of pileo- and caulocystidia (although *P. conopilus* (Fr.) Örstadius & E. Larss. and *P. auricoma* (Pat.) Redhead et al. do possess sclerocystidia; Nagy et al. 2010, Schafer 2014).

Index Fungorum (www.indexfungorum.org) lists 22 species under *Parasola*, although other taxonomic treatments recognize a lower number (Nagy et al. 2009, 2010; Schäfer 2010, 2014). These mushrooms, which are common decomposers of leaf-litter, wood, and herbivore dung, are distributed world-wide, with most of the records from Europe, North America, South America,

Australasia, and Africa (Pegler 1966, 1983; Grgurinovic 1997; Pennycook 2004; Schafer 2014) and some from Asia (Ahmad 1980; Pegler 1986).

The lilaceous coloration reported for the pileus in *P. lilatincta* (Uljé & Bender 1997) is not always found (Nagy 2007). The phylogeny of *Parasola* and other coprinoid fungi suggest that morphological variations like spore size, shape and position of germ pore, and presence/absence of lilaceous granules in the tissues are species delimiting characters (Nagy et al. 2009, 2012, 2013).

Only three *Parasola* species (*P. auricoma* (Pat.) Redhead et al., *P. plicatilis* (Curtis: Fr.) Redhead et al. and *P. setulosa* (Berk. & Broome) Redhead et al. have been reported previously from Pakistan (Ahmad 1980), all morphologically identified. In this study we characterized a fourth species for Pakistan using morphological and phylogenetic criteria: *P. lilatincta.* Our work also offers the first phylogenetic confirmation of *Parasola* from the country.

Materials & methods

Sampling

Samples were collected in August of 2013 and 2014 from district Malakand, KP, Pakistan (34°33–56'N 71°52–55'E), which features a subtropical climate with heavy annual rainfall (600–1100 mm) and high temperatures during monsoon (Karim 2008).

Basidiomata were found on leaf-litter, photographed, and tagged. Macroscopic features like color, shape, and size of pileus and stipe and gill attachment were noted in the field. Colors were designated according to Munsell (1975). Air-dried samples were stored in zip-lock bags prior to anatomical and molecular characterization in the lab. Specimens are conserved in the Herbarium, Hazara University, Dhodial, Mansehra, Pakistan (HUP).

Microscopical examination

Slides were prepared in 5% aqueous KOH (w/v) and lactic acid. Basidiospore size and shape, basidia, cheilocystidia, and germ pore position were studied under a light Meiji MX4300H microscope, and at least 20 measurements were recorded for each character, except that 48 basidiospores were measured in face view and/or side view through 100× oil immersion. Basidiospore measurements (rounded to the nearest 0.5 µm) are presented as follows: length range × breadth range × width range. Q values were calculated as: Q_1 = length divided by breadth; Q_2 = length divided by width (Nagy et al. 2010). Average length, breadth, and width of all basidiospores are given by avX. Line drawings were made with camera lucida.

DNA extraction, PCR amplification, and DNA sequencing

For DNA extraction, a small piece (20–40 mg) of gill was kept in 2% CTAB buffer, following Bruns (1995) with some modification. The ITS-nrDNA region was amplified using the universal primer pair ITS-1F and ITS-4 (White et al. 1990). The polymerase chain reaction (PCR) was performed in 20 µL reaction volume containing 1 µL genomic DNA, 0.1 µL of each primer in 100 pmol/µL concentration, 10 µL MasterMix (Sigma-Aldrich Co. LLC), and 8.8 µL deionized distilled water according to Gardes & Bruns

(1993) with PCR parameters set at one cycle at 94 °C for 1 min, 35 cycles at 94 °C, 53 °C and 72 °C each for 1 min, with a final extension at 72 °C for 8 min. The amplified products were run through 1% agarose gel stained with ethidium bromide and visualized under UV light Gel Documentation System (UVtec, Avebury House, Cambridge CB4 1QB UK), using default settings. The PCR products were directly sequenced in both directions using the same primer set through Automatic Sequencer 3730XL (Macrogen Korea). ITS sequences generated from this study as well as other sequences retrieved from GenBank were aligned through ClustalW followed by manual adjustment in BioEdit (www.mbio.ncsu.edu/bioedit/bioedit.html) to construct DNA dataset. Phylogeny based on 30 ITS sequences (including outgroup *Coprinus comatus* AY635772) was

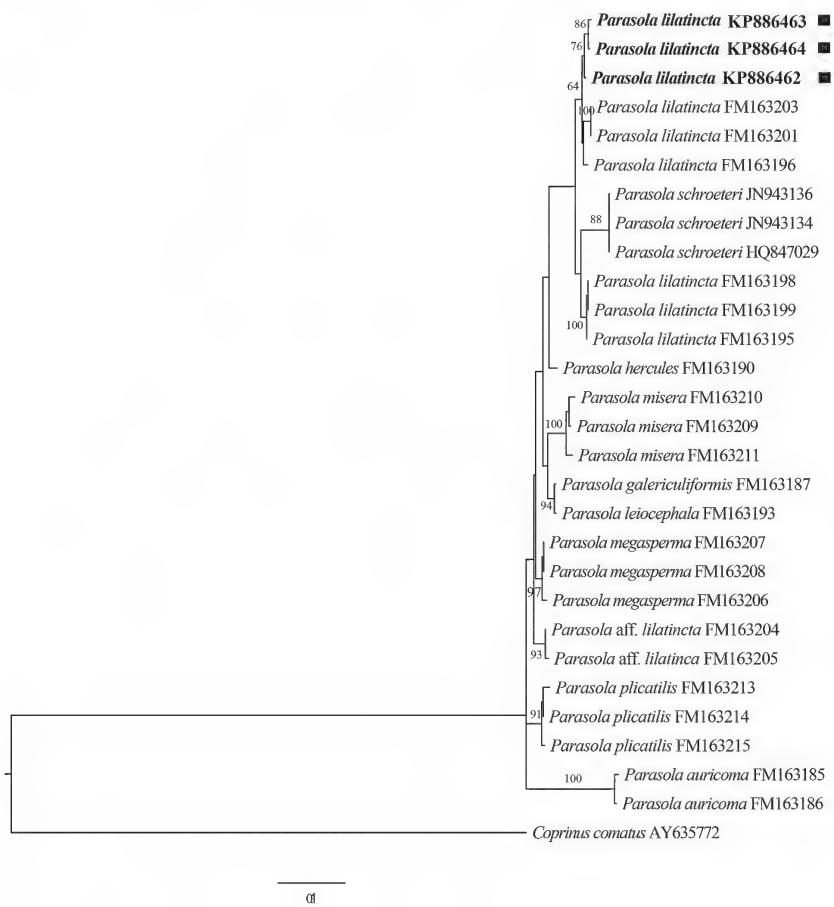

FIG. 1: ITS phylogeny of *Parasola* sequences, including Pakistani sequences of *P. lilatincta* with boldface represented by (▪), inferred by the maximum likelihood method. Bootstrap support is indicated for selected nodes.

analyzed by Maximum Likelihood (ML). Phylogenetic tree was constructed through the RAxML-HPC BlackBox (8.1.11) with default setting via CIPRES Science Gateway (Miller et al. 2010).

Results

Phylogenetic analysis

Three ITS sequences of *Parasola lilatincta* were generated for this study (Fig. 1); other sequences (including the outgroup) were retrieved from GenBank. Our phylogenetic analysis closely associates the Pakistani sequences with other *P. lilatincta* sequences, but the clade structure was not well supported.

Taxonomy

Parasola lilatincta (Bender & Uljé) Redhead, Vilgalys & Hopple, Taxon 50: 236. 2001. Plates 1, 2

Pileus 15–20 mm, broadly convex to applanate, deeply plicate and membranous and smooth, light grayish brown (7.5YR 5/2–6/2); center slightly depressed, light orange (7.5R 5/2); sulcate straight margin, lacking any velar structure. Gills free, even, distant, initially concolorous with the pileus, later blackish, and finally collapsed. Stipe 40–70 × 2–4 mm, equal, central, hollow; surface smooth, snow-white.

Basidiospores [48/4/3]; (12.4)13.5–15(16.4) × (10)10.5–11(11.7) × (8.1)8.5–9.5(10.2) µm, [av*X* = 14.4 × 10.8 × 9.2; Q1 = 1.3–1.4, Q2 = 1.3–1.5, avQ = 1.4], in face view lentiform to rounded triangular, in side view ellipsoid; dark brown, germ pore 1.7–2.7 µm and eccentric, wall ≤2 µm thick. Basidia 17–23 × 6–9 µm, clavate to cylindrical, di- to tetrasporic, light brown, smooth. Cheilocystidia 25–32 × 6–9 µm, cylindrical, hyaline. Pileipellis 28–34 × 9–12 µm, clavate, hyaline, smooth with greenish oil droplets. Pleurocystidia absent.

Specimens examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, Malakand, Qaldara, ca. 510 m, on leaf litter, 3 Aug. 2013, Shah Hussain (HUP–SHP2; GenBank KP886463); 10 Aug. 2014, Shah Hussain (HUP–SHP4; GenBank KP886462); 14 Aug. 2014, Shah Hussain (HUP–SHP9; GenBank KP886464).

Comments

In this study we describe *P. lilatincta* morpho-anatomically and phylogenetically as a new record for Pakistan. Proper identification of *Parasola* species is often difficult due to minor anatomical differences separating them. Basidiospore size and shape are the two main diagnostic characters used to distinguish species in this group (Nagy et al. 2009). Based on spore shape and germ pore position, *P. lilatincta* is a close relative of *P. leiocephala* (P.D. Orton) Redhead et al. and *P. schroeteri* (P. Karst.) Redhead et al.

Plate 1: Basidioma of *Parasola lilatincta* (HUP-SHP9). Scale bar: 10 mm.

We observed lilaceous tints in the pileipellis of different Pakistani collections. However, Nagy et al. (2010) did not find any such structures in the type material. Occurrence of oil contents in the pileipellis during this study suggest that the lilaceous tints may be a character of fresh material.

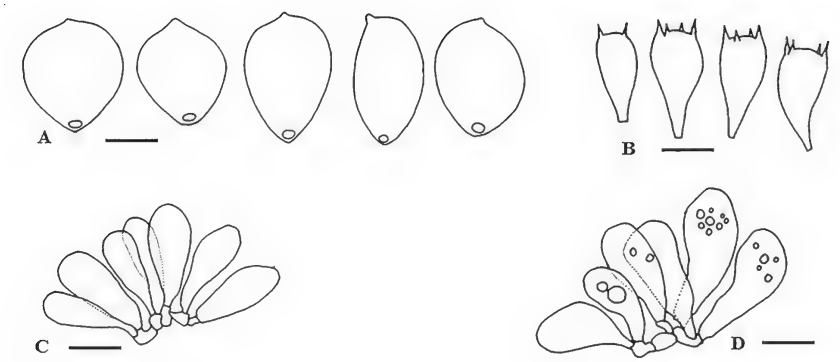

Plate 2: *Parasola lilatincta* (HUP-SHP2).
A: basidiospores; B: basidia; C: cheilocystidia; D: pileipellis elements.
Scale bars: A = 5 µm; B–D = 10 µm.

The lilaceous tints in hyphae, lentiform basidiospores, and sequence analyses all support the identification of the Pakistani collections as *P. lilatincta*.

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Pseudocercospora picrasmicola sp. nov. and a new record of *P. paludicola* from China

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Abstract — *Pseudocercospora picrasmicola* on *Picrasma quassioides* is introduced as a new species, based on Chinese specimens previously misdetermined as "*Prathigada picrasmae.*" *Pseudocercospora paludicola* on *Persicaria chinensis* is reported as new to China. The two species are described, illustrated, and discussed. Examined specimens are deposited in the Herbarium of the Institute of Microbiology, Chinese Academy of Sciences, Beijing (HMAS).

Key words — anamorphic fungi, *Passalora*, *Cercospora*, *Polygonum,* taxonomy

Introduction

In this study we reassess *Prathigada picrasmae* (Togashi & Katsuki) X.J. Liu & Y.Z. Liao. The thin inconspicuous conidiogenous loci of the Chinese material on which Liu & Liao (1980) based this new combination conform with *Pseudocercospora* Speg., and the Chinese fungus is not conspecific with the Japanese *Cercospora picrasmae* Togashi & Katsuki. Thus "*Prathigada picrasmae*" sensu Liu & Liao (1980) is a misapplied name, and this taxon is described here as a new species, *Pseudocercospora picrasmicola*, with the original specimen of Liu & Liao (1980) as holotype and an additional specimen identified by Guo (1996) as a paratype.

A cercosporoid fungus found on *Persicaria chinensis*, identified as *Pseudocercospora paludicola*, represents a new record for China.

Materials & methods

Type material of the new species was collected on living leaves of *Picrasma quassioides* in Taibai Mountain, Shaanxi Province; additional material was collected on the same host in Liuba, Shaanxi Province. *Pseudocercospora paludicola* was found on leaves of *Persicaria chinensis* in Kuankuoshui protection zone, Guizhou Province. Samples from the three collections were mounted in distilled water and examined using oil immersion (bright field and phase contrast) with an Olympus CX 21 light microscope. Thirty measurements (400× magnification) were made of conidia and other structures. All specimens are deposited at the Mycological Herbarium of Academia Sinica (HMAS), Beijing.

Taxonomy

Pseudocercospora picrasmicola Y.L. Guo, F.Y. Zhai & Ying J. Liu, **sp. nov.** Fig. 1

MycoBank MB 810159

Differs from other *Pseudocercospora* spp. on simaroubaceous hosts by its rostrate conidia with unequally colored cells and thick-walled septa.

Type: China, Shaanxi Province, Taibai Mountain, on leaves of *Picrasma quassioides* (D. Don) Benn. (*Simaroubaceae*), 13 X 1963, coll. Q.M. Ma & Y.C. Zong (**Holotype**, HMAS 10266).

Misapplied name: "*Prathigada picrasmae*" sensu Liu & Liao (1980).

Etymology: referring to the host genus *Prasmicola*.

Leaf spots amphigenous, subcircular, 1–3 mm diam., often confluent, grayish white to pale brown, margin surrounded by a brown to dark brown line, with an olivaceous-brown to pale brown halo on the upper surface, on the lower surface angular, margin indistinct, limited by veins, 1–4 mm wide. Caespituli hypogenous. Mycelium internal. Stromata subepidermal, globose, dark brown, 25–40 µm diam. Conidiophores loosely to densely fasciculate, olivaceous to pale olivaceous-brown, uniform in color, irregular in width, straight to curved, not branched, 0–1-geniculate, thick-walled, smooth, rounded to conical or conically truncate at the apex, 1–3-septate, 13–50(–75) × 4.0–5.8 µm. Conidiogenous cells integrated, terminal, 10–25 µm long. Conidiogenous loci inconspicuous, thin, planate, 2–3 µm wide. Conidia solitary, obclavate, rostrate, pale olivaceous-brown to moderately dark olivaceous-brown with cells unequally colored, thick-walled, smooth, straight to curved, obtuse at the apex, obconically truncate at the base, 2.4–4.0 µm wide, 3–11-septate, septa rather thick and dark, sometimes constricted at the septa, 45–95(–128) × 4.7–8.0(–9.3) µm.

Additional collection examined: **China. Shaanxi Province**, Liuba, on leaves of *Picrasma quassioides*, 20 IX 1991, coll. Y.L. Guo 2072 (HMAS 69480).

Notes: Togashi & Katsuki (1952) described *Cercospora picrasmae* on *Picrasma quassioides* [= *P. ailanthoides* (Bunge) Planch.] from Japan as:

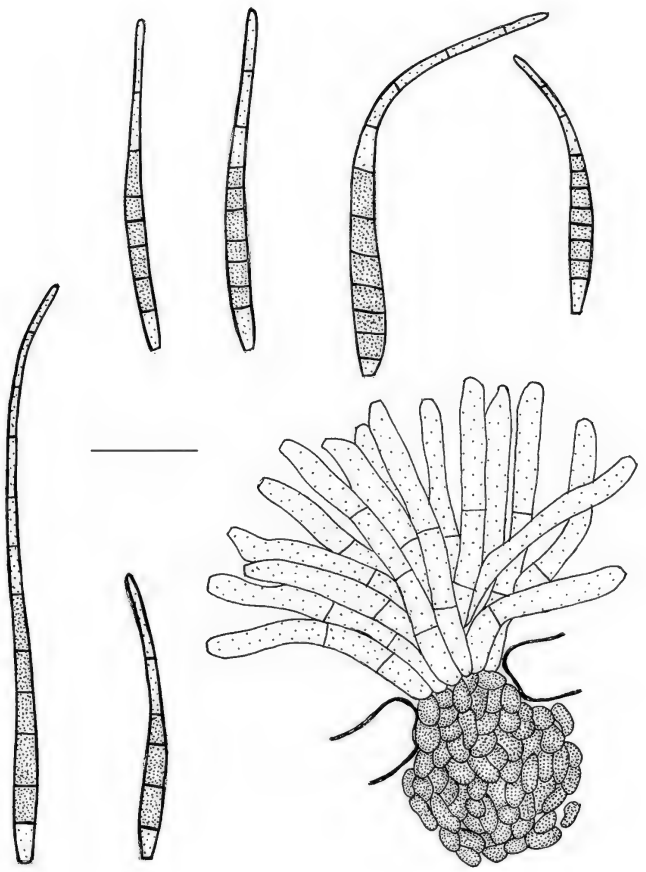

FIG. 1. *Pseudocercospora picrasmicola* (holotype, HMAS 10266). Conidiophores and conidia. Scale bar = 10 μm.

> "leaf spots 0.5–3.0 mm diam.; fruiting hypophyllous; stromata globose, brown, 15.0–50.0 μm diam.; conidiophores very pale olivaceous-brown, aseptate, without geniculate point, 15.0–43.0 × 3.4–5.0 μm; conidia obclavate, pale olivaceous, 2–7-septate, 25.0–85.0 × 4.0–5.5 μm."

Liu & Liao (1980) studied a Chinese cercosporoid specimen on the same host, and in spite of significant morphological differences this collection was identified as *Cercospora picrasmae*. Type material of this species was not available for comparison; but based on their Chinese material having conidia

with unequally colored cells and long beaks, Liu & Liao (1980) transferred *C. picrasmae* to *Prathigada*. However, the conspecificity of the Chinese *Prathigada*-like fungus and authentic Japanese *C. picrasmae* is untenable and based on a misinterpretation of the Japanese *Cercospora* species, which is morphologically quite distinct in its aseptate conidiophores and uniformly pale olivaceous and much narrower conidia without beaks. Re-examination of type material and additional Japanese collections is necessary to elucidate the genuine generic affinity of *C. picrasmae,* which is tentatively retained in *Cercospora*.

There are only a few other *Pseudocercospora* spp. on hosts belonging to the *Simaroubaceae*, but their conidia are not rostrate, lack unequally colored cells, and have thin-walled septa.

Pseudocercospora ailanthicola (Patw.) Deighton on *Ailanthus excelsa* Roxb. differs from *P. picrasmicola* in forming indistinct leaf spots, lacking stromata, and in producing smaller (26.5–39.5 × 3–4.5 µm) pale brown conidiophores with 3–4 conspicuous scars and much smaller (20–63 × 3–5 µm) olivaceous to pale brown conidia that gradually narrow towards the apex (Patwardhan 1963). Another species described from *A. excelsa*, *P. ailanthigena* H.S.G. Rao et al., is conspecific with *P. ailanthicola* (Kamal 2010).

Pseudocercospora qinlingensis Y.L. Guo parasitizing *Ailanthus* sp. differs from *P. picrasmicola* in possessing amphigenous fruiting, larger stromata (40–100 µm), shorter conidiophores (6.5–26 × 3.9–6 µm), and cylindrical, darker (olivaceous-brown to moderate brown) conidia that are uniformly colored, strongly curved, and slightly longer and narrower (32–150 × 4–7.6 µm; Guo 1996).

Pseudocercospora simaroubae U. Braun & F.O. Freire on *Simarouba versicolor* A. St.-Hil. differs from *P. picrasmicola* in lacking or producing only small stromata, occasionally forming branched, broader (3–7 µm), (0–)1–6-septate conidiophores with 10–25 µm long conidiogenous cells and inconspicuous to sub-conspicuous conidiogenous loci, and obclavate to cylindrical and smaller (15–60 × 3–7 µm) conidia with 1–8 septa; Braun & Freire 2003).

Pseudocercospora paludicola (Speg.) U. Braun, Schlechtendalia 5: 67, 2000. Fig. 2
≡ *Cercospora paludicola* Speg., Anales Soc. Ci. Argent. 13: 29, 1882.

Leaf spots amphigenous, angular to irregular, 1–4 mm diam., margin indistinct, often confluent, brown to dark brown, with yellowish to pale brown halo on the upper surface, paler on the lower surface. Caespituli hypogenous. Primary mycelium internal. Secondary mycelium external, hyphae emerging through stomata, pale olivaceous to olivaceous, branched, septate, 1.3–2.5 µm wide. Stromata none or small, substomatal, dark brown.

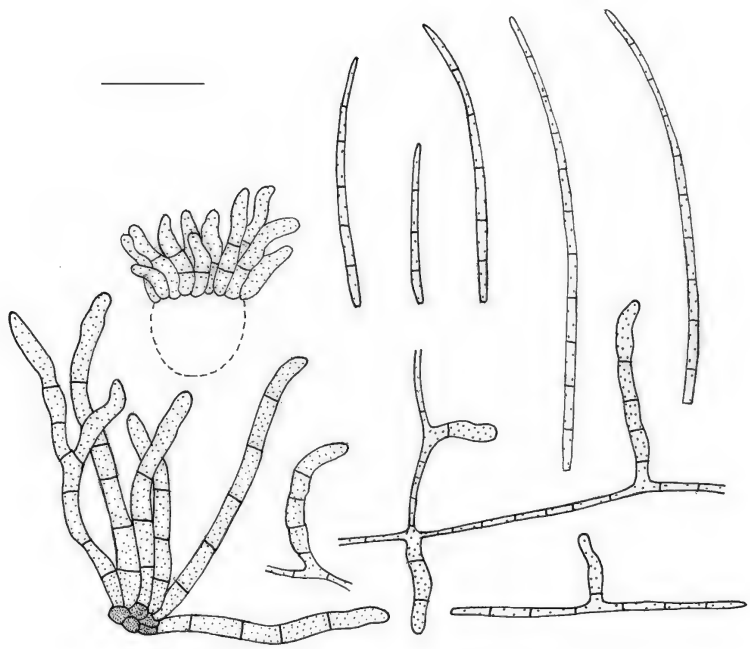

Fig. 2. *Pseudocercospora paludicola* (HMAS 244890).
Conidiophores and conidia. Scale bar = 20 μm.

Conidiophores emerging through stomata, densely fasciculate or solitary, arising from external hyphae as lateral branches, pale olivaceous-brown, uniform in color, thin-walled, smooth, irregular in width, straight to slightly curved, branched, slightly geniculate, rounded to conical at the apex, 1–7-septate, constricted at the septa, 10–80 × 2.5–5 μm. Conidiogenous cells terminal, 6–19 × 1.8–4.4 μm. Conidiogenous loci inconspicuous. Conidia solitary, cylindrical, pale olivaceous to olivaceous, thin-walled, smooth, straight to curved, obtuse at the apex, obconically truncate and 1.2–1.6 μm wide at the base, 3–10-septate, 35–125 × 2.5–3.7 μm.

Collection examined: **China. Guizhou Province**, Kuankuoshui protection zone, on leaves of *Persicaria chinensis* (L.) H. Gross, 16 IX 2013, coll. Y.L. Guo 73 (HMAS 244890).

Notes: This is the first report of *P. paludicola* (previously known only from Argentina) from China. Guo (1993) identified a fungus on *Polygonum aviculare* L. (HMAS 65900) from Xiao Wutai Mountain, Hebei Province, with thickened conidiogenous loci and pigmented conidia as *Cercospora paludicola*, based on Chupp's (1954) description of this species. Braun (2000), who

examined the Argentinian type specimen of *C. paludicola*, found unthickened and unpigmented conidiogenous loci and hila and transferred the species to *Pseudocercospora*. After Guo & Li (2002) re-examined the Chinese fungus on *Polygonum aviculare,* they described it as a new species, *Passalora polygoni* Y.L. Guo.

In contrast to *Passalora polygoni*, our Chinese collection on *Persicaria chinensis* represents a genuine *Pseudocercospora* species, morphologically very similar to Spegazzini's (1882) description of *C. paludicola* (conidiophores 5–25 × 2–3.5 µm, conidia 30–150 × 2–3.5 µm), only differing in having longer conidiophores and somewhat shorter conidia.

Two other *Pseudocercospora* species, *P. persicariae* (W. Yamam.) Deighton on *Polygonum* and *Persicaria* spp., and *P. polygonicola* (A.K. Kar & M. Mandal) Deighton on *Polygonum* spp. are somewhat similar to *P. paludicola*, but they do not form angular leaf spots, they lack superficial hyphae, and their conidia are broader and mainly obclavate (Chupp 1954; Kar & Mandel 1969).

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Acrodictys, Corynespora, Karstenula, Oncopodium, and *Sporocadus:* new genera for Turkey

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Abstract—Five microfungal genera are recorded for the first time in Turkey. Brief morphological descriptions based on collections from Kırşehir province are provided for *Sporocadus pezizoides* (*Phlogicylindriaceae*), *Corynespora cambrensis* (*Corynesporascaceae*), *Karstenula rhodostoma* (*Montagnulaceae*), *Acrodictys elliptica* (*Pezizomycotina*), and *Oncopodium elaeagni* (*Pezizomycotina*).

Key words—anamorphic fungi, Anatolian Peninsula, *Ascomycota*, biodiversity

Introduction

Most studies on micromycetes in Turkey have focused on powdery mildews (*Erysiphales*) and rusts (*Pucciniales*). Other microfungi, especially the asexual states of saprobic ascomycetes that develop on forest trees and bushes, are insufficiently studied. However, in the last fifteen years the research on these fungi has increased (Akgul et al. 2015; Hüseyin 2004; Hüseyinov & Selçuk 1999, 2001; Hüseyinov 2000; Hüseyin & Selçuk 2001, 2002a,b, 2014; Selçuk et al. 2003, 2009, 2012a,b, 2014; Mel'nik et al. 2004; Selçuk & Ekici 2014; Selçuk & Hüseyin 2014; Hüseyin et al. 2005, 2014; Vasighzadeh et al. 2014).

Kırşehir province (38°50′–39°50′N 33°30′–34°50′E) is located in the middle of Anatolian Peninsula. This area lies within the Irano-Turanian phytogeographic region. According to the data obtained from the Kırşehir meteorological station, annual precipitation is 340–400 mm and the annual average temperature is 11°C.

This study contributes to the list of mycobiota of Turkey by adding five new genera.

Materials & methods

The specimens were collected during periodical mycological excursions in Boztepe district, Kırşehir Province, between 2012 and 2014. Microscopic studies were carried out on slides, with the samples prepared in distilled water. Morphological features were examined using an Olympus BX 53 research microscope (Japan) and Axio Imager 2 microscope equipped with Nomarski differential interference contrast optics. Hyphomycetous genera were identified via the key by Seifert et al. (2011). Species were identified by consulting handbooks and other publications (Ellis 1960, Sutton 1980, Dennis 1981, Morelet 1985, Ellis & Ellis 1987, Manoharachary et al. 2006, Magyar & Révay 2009). The host plants were identified using "Flora of Turkey and East Aegean Islands" (Davis 1965–85). Taxonomic names and citations follow Kirk et al. (2008) and Kirk (2015). All specimens are deposited in the Mycological Collection, Department of Biology, Arts and Sciences Faculty, Ahi Evran University, Kırşehir, Turkey (AEUT).

Taxonomy

Sporocadus pezizoides (Ellis & Everh.) M. Morelet, Ann. Soc. Sci. Nat. Archéol. Toulon Var 37(4): 234 (1985)

Conidiomata dark brown, sporodochial to disciform, 300–400 µm wide, 80–100 µm deep. Conidiophores hyaline, simple, cylindrical, 17.5–25 × 1.5–3 µm. Conidia brown, dark brown, straight or curved, clavate to fusiform with rounded ends, 25–30 × 7–8(–10) µm, 3-septate, septa prominent and very dark brown.

Specimens examined: **TURKEY, Kırşehir Province,** Boztepe district, around Kervansaray mountain, 39°13′10″N 34°13′55″E, 1300 m a.s.l., on dead wood of Salix alba L., 20.IV.2013, Kadriye Ekici 203 (AEUT); 30.III.2014, Kadriye Ekici 203a (AEUT).

Comments: The Turkish specimens of *Sporocadus pezizoides* have more slender conidiophores and narrower conidia than those described by Morelet (1985; conidiophores 2.5–3 µm wide, conidia 8.5–10.5 µm wide).

Corynespora cambrensis M.B. Ellis, Mycol. Pap. 76: 28 (1960)

Colonies on the natural substratum effuse, hairy, dark blackish brown. Mycelium superficial and immersed. Hyphae branched, 4–5 µm diam. Conidiophores simple, septate, dark brown, (45–)50–55(–65) × 5–7 µm. Conidia dark brown, smooth, (5–)8–12-pseudoseptate, cylindric, (23–)25–57 (–75) × (7.5–)8–10 µm.

Specimens examined: **TURKEY, Kırşehir Province,** Boztepe district, around Kervansaray mountain, 39°12′50″ N 34°13′01″ E, 1440 m a.s.l., on dead wood of *Salix cinerea* L. trunk, 27.IV.2013, Kadriye Ekici 207 (AEUT).

Comments: The Turkish specimen of *Corynespora cambrensis* has wider conidia with more numerous pseudosepta than described for the type specimen (Ellis 1960; 5–10 µm wide, with 2–8 pseudosepta).

Karstenula rhodostoma (Alb. & Schwein.) Speg., Dec. Mycol. Ital. 7–12: no. 94 (1879)

Pseudothecia gregarious beneath the bark, blackish or black, globose, globose-depressed, 450–550 µm diam. Hymenium paraphysate. Asci 8-spored, cylindrical, apically rounded, (115–)130–135(–160) × 12.5–18 µm, with thick and short stalk. Ascospores dark brown, guttulate, uniseriate, 3-septate, constricted at the septa, cylindrical, fusiform, rounded at both ends, 22.5–25 × 8–9.5 µm.

Specimen examined: **TURKEY**, **Kırşehir Province**, Boztepe district, around Kervansaray mountain, 39°13′30″ N 34°14′10″ E, 1320 m a.s.l., on dead branches of *Rhamnus petiolaris* Boiss. & Balansa, 02.XII.2012, Kadriye Ekici 191 (AEUT).

Comments: The Turkish specimen of *Karstenula rhodostoma* has wider asci and ascospores than those described by Dennis (1981; asci 12 µm wide, ascospores 7–9 µm wide).

Acrodictys elliptica Manohar., N.K. Rao, D.K. Agarwal & Kunwar, Indian Phytopath. 59: 91 (2006)

Colonies on the natural substratum effuse, hairy, brownish black, black, 5–10 × 1–2 mm. Mycelium mostly immersed. Hyphae smooth, brown, 3–3.5 µm diam. Conidiophores simple, septate, brown to black, erect, usually straight or slightly flexuous, 30–70 × 4–8 µm. Conidia dark brown, smooth, with 3–4 transverse and 1–2 longitudinal septa, ellipsoidal, ovoid, slightly constricted at the septa, (16–)17.5–22.5(–25) × (8–)9–12.5 µm.

Specimen examined: **TURKEY**, **Kırşehir Province**, Boztepe district, around Kervansaray mountain, 39°12′05″ N 34°13′08″ E, 1380 m a.s. l., on dead wood of *Cotoneaster nummularius* Fisch. & C.A. Mey., 04.XI.2012, Kadriye Ekici 62 (AEUT).

Comments: The Turkish specimen of *Acrodictys elliptica* has conidia with more transverse septa and fewer longitudinal septa but otherwise morphologically close to the type description (Manoharachary et al. 2006; 2–3 transverse and 2–3 longitudinal septa).

Oncopodium elaeagni D. Magyar, Nova Hedwigia 88: 477 (2009)

Colonies on the natural substratum brown. Mycelium immersed. Hyphae septate, smooth, brown, 4–5 µm diam. Conidiomata sporodochial, black. Conidiophores caespitose, septate, hyaline, 15–40 × 2.5–4.5 µm. Conidia fusiform, limoniform, brown, smooth, with 6–7 transverse and 3–4 longitudinal septa, 25–31 × 12–13(–14) µm, with 2 lateral and 1 central horn-like cells.

Specimen examined: **TURKEY**, **Kırşehir Province**, Boztepe district, around Kervansaray mountain, 39°13′10″N 34°13′40″ E, 1320 m a.s.l., on dead bark of *Elaeagnus angustifolia* L., 27.VII.2013, Kadriye Ekici 134 (AEUT).

Comments: The Turkish specimen of *Oncopodium elaeagni* has conidia that do not differ significantly in size from that cited by Magyar & Révay (2009: 24–30 × 9–18 µm).

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Merismatium, *Porpidia* and *Protoparmelia* spp. new for Turkey and Asia

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Abstract — Three lichen species collected from the Muş and Burdur regions (*Merismatium deminutum*, *Porpidia zeoroides*, *Protoparmelia atriseda*) have been determined as new to Turkey and Asia. Descriptions are accompanied by notes on geographic distribution and chemistry and comparisons with morphologically similar taxa.

Key words — *Ascomycota*, biodiversity

Introduction

Recent studies on the lichen biota of Turkey have contributed many new records for the country (Aptroot & Yazıcı 2012; Arslan et al. 2011; Yazıcı et al. 2010a,b,c; 2011a,b 2012; Karagöz & Aslan 2012; Karagöz et al. 2011; Kinalioglu & Aptroot 2011; Osyczka et al. 2011; Vondrák et al. 2012). However, there are still many lichenologically unexplored parts in Turkey and more explorations of those regions are needed.

Although approximately 650 lichen taxa have been noted from Turkey, including 389 taxa from Burdur province (Aptroot et al. 2015, Aslan & Yazici 2013, Çobanoğlu 2005, Öztürk et al. 2005, Pišút & Guttová 2008, Şenkardeşler 2009, Yazici et al. 2013, 2015), no lichen taxa have thus far been reported from the Muş region. Within our projects "Lichen and bryophyte flora of Burdur provinces" and "Lichen flora of Muş and Bitlis Provinces" we identified three lichens as new records for Turkey and for Asia.

Materials & methods

Kenan Yazici collected lichen samples in May, June, and July during a 2015 lichenological survey of the Muş and Burdur regions.

The Muş region (center, Bulanık and Varto districts) primarily encompasses vast areas of meadow, large plains, and steppe but no high mountains or canyons are seen (Baytop & Denizci 1963). Collecting localities are well-lit, windswept, treeless areas with gently sloping terrain containing streams, grass, and calcareous and siliceous rocks. The region's climate is characterized by very cold snowy winters and short hot dry short summers, with temperatures ranging from −29 to 41.6°C. Annual rainfall ranges from 350–1000 mm and the average humidity is 60.3% (Akman 1999).

The Burdur region (center, Kemer and Altınyayla districts) is mountainous and heavily forested with intermittent streams, lakes, and dams (Baytop & Denizci 1963). Forest tree species include *Abies*, *Cedrus*, *Ficus*, *Fraxinus*, *Juniperus*, *Olea*, *Pinus*, *Pistacia*, *Prunus*, *Quercus* (especially Altınyayla district), and *Rhus*. The subcanopy flora is very abundant although the nearby mountains are covered with marble rocks. The region has a continental Mediterranean climate characterized by cold snowy winters and very hot long dry summers. Temperatures range from −16 to 39°C with a mean annual temperature of 15°C, and the mean annual rainfall is about 468 mm with an average humidity of 51.2% (Akman 1999).

Samples were examined using a Nikon SMZ1500 stereomicroscope and Nikon Eclipse 80i compound light microscope and identified by consulting the relevant keys (Clauzade & Roux 1985, Hawksworth et al. 2010, Nash et al. 2001, Orange 2013, Poelt & Leuckert 1991, Roux et al. 2002, Smith et al. 2009).

The descriptions are based on Turkish specimens and vouchers are stored in the Herbarium of the Biology Department, Karadeniz Technical University, Trabzon, Turkey (KTUB).

Taxonomy

Merismatium deminutum (Arnold) Cl. Roux & Nav.-Ros.,
Mycotaxon 84: 3(2002) Fig. 1

Thallus immersed clearly, white to greyish white, thin, tartareous, perithecia in pits, numerous, with protecting, globose, immersed, minute, to 0.15 mm diam., leaving pits in the rock; involucrellum present; perithecial wall entire, with branched and anastomosing hyphae; cortical cells without papillae; exciple dark pigmented, brown to dark brown, K+ dark brown, with faint violet pigment around the ostiolar region; hyphae surrounding exciple colourless to brownish, either I− or I + violet. Hymenium without photobiont, hamathecial interascal filaments absent. Asci 8-spored, ascospores pale to dark brown, with a distinct perispore, (18–)22–29(–31) × 8–14 µm, ellipsoid or broadly oblong, muriform with 5–8 transverse septa and 6–15 cells.

Specimens Examined – **TURKEY. Muş:** Varto, Çallıdere village, roadside, 39°16′25″N 41°14′18″E, 1705 m, on calcareous rock, 01.07.2015, leg. Kenan Yazıcı. (KTUB–2422); **Burdur:** Center, towards Ulupınar village, roadside, 37°44′40″N 30°00′02″E, 1434 m, on calcareous rock, 25.06.2013, leg. Kenan Yazici. (KTUB–2451).

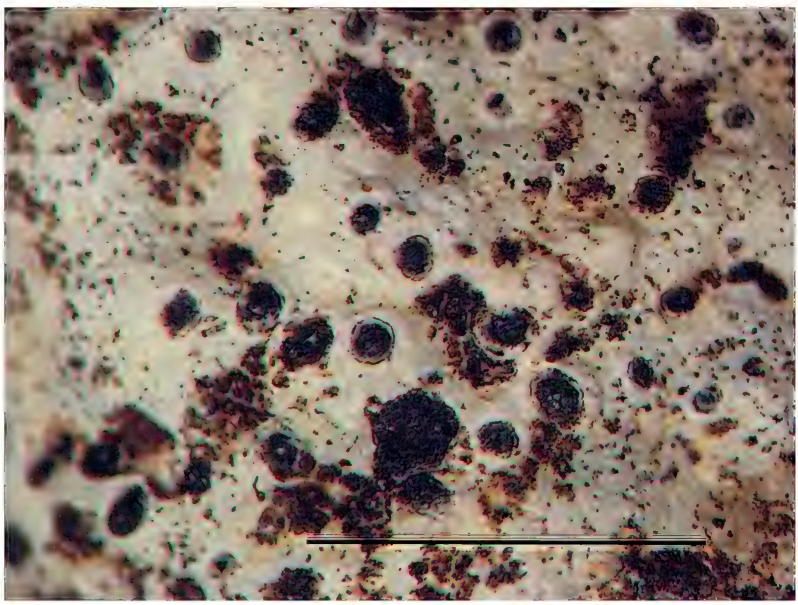

FIG. 1. *Merismatium deminutum* (KTUB-2422), habitus. Scale = 1 mm

REMARKS—A detailed description is provided by Roux et al. (2002). *Merismatium deminutum* is similar to *M. discrepans* but differs by its larger spores with thick perispores. Both species occasionally grow parasitically on other lichens *M. deminutum* on *Staurothele orbicularis* and *M. discrepans* on species of *Catapyrenium*, *Protoblastenia, Aspicilia*, *Catillaria*, and *Hymenelia.*

Species associated with our specimens were *Acarospora cervina*, *Aspicilia cinerea*, *Candelariella vitellina*, *Lecanora dispersa*, *Placynthium nigrum, Protoparmeliopsis muralis, Verrucaria nigrescens*, and *V. parmigerella.* Previously known from Europe (England, Russia, Spain), *M. deminutum* is new to Turkey and Asia.

Porpidia zeoroides (Anzi) Knoph & Hertel, Mitt. Bot. Staatssamml. München 20: 477 (1984) FIG. 2

Thallus crustose, continuous, developed, pale white to chalk or ± grey white; surface, cracked, pruinose, papillose, verrucose, warty, rimose-areolate, fissured, to 6.5 cm diam., 2.5 mm thick; apothecia black, sessile, superficial disc, pruinose clearly, to 1.5–2 mm diam., flat, flattened, expanded, convex with receding margin later; medulla I–; hymenium 90–145 µm; hypothecium brown,

FIG. 2. *Porpidia zeoroides* (KTUB-2425), habitus. Scale = 1 mm

black-brown, with crystals; epihymenium pale brown to brown; excipulum developed, interior brown, fawn, with broad, relatively weakly pigmented outer region; asci 8-spored, *Porpidia*-type; ascospores 17–29 × 7–13 µm, ellipsoidal, lumen unilocular, hyaline, perispore; epispore absent, thin; conidiomata absent; conidia bacilliform; photobiont *Trebouxia*.

SPECIMENS EXAMINED – **TURKEY. MUŞ:** CENTER, 200 m to Alaniçi village, roadside, 38°39′16″N 41°21′11″E, 1709 m, on calcareous rock, 29.05.2015, leg. Kenan Yazıcı. (KTUB–2425), **BURDUR:** KEMER, 3 km to Bozdağ, Bozdağ-Akpınar plateau, 37°19′37″N 30°04′45″E, 1425 m, on calcareous rock, 07.04.2013, leg. Kenan Yazıcı. (KTUB–2449).

REMARKS— A detailed description of *Porpidia zeoroides* is provided by Smith et al. (2009). *Porpidia shangrila,* a similar species that also grows on calcareous rocks, differs by its endolithic thallus, and bluish green epihymenium. *Porpidia superba* is distinguished from *P. zeoroides* by its black apothecia and epithecium with an olivaceous pigment.

Porpidia zeoroides occurs mainly on calcareous rocks. Species associated with our specimens were *Acarospora cervina, Aspicilia caesiocinerea*, *Candelariella vitellina, Placynthium nigrum*, and *Protoparmeliopsis muralis*. Previously known from Europe and North America, *P. zeoroides* is new to Turkey and Asia.

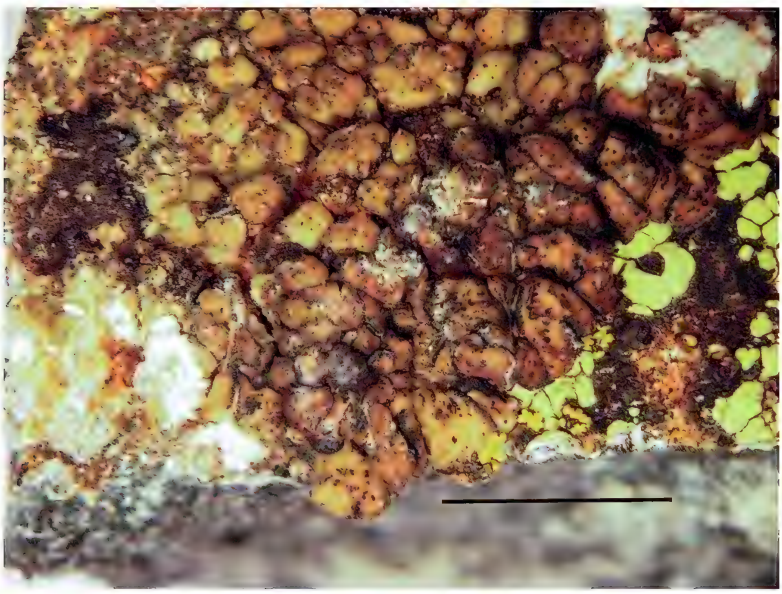

FIG. 3. *Protoparmelia atriseda* (KTUB-2426), habitus. Scale = 1 cm

Protoparmelia atriseda (Fr.) R. Sant. & V. Wirth, Die Flechten Baden-Württembergs, Verbreitungsatlas: 511 (1987) FIG. 3

Thallus crustose light brown to ±brown, glossy, ±developed, forming patches, to 3.5 cm across, ± thick, verrucae or areoles; areoles not compacted, convex or ± hemispherical, 0.4–0.9 mm in diam. Apothecia ± numerous, immersed at first, ≤1 mm diam.; disc chestnut brown to red-brown, convex; margin, thin, entire, later disappearing; exciple, concolorous with the thallus; epihymenium ±olive-brown; hymenium, hyaline, 45–50 µm tall, I+ blue; paraphyses coherent, ± brown at tips; asci clavate, 8-spored; ascospores hyaline, simple, oblong-ellipsoid to oblong with rounded ends, 7–14 × 4–6.5 µm. Pycnidia rare, immersed; conidia filiform, curved, 16–25 µm long. Cortex and apothecia (in sections) K+ yellow to red, C–, KC–, P+ yellow or orange, UV–, norstictic acid.

SPECIMENS EXAMINED – **TURKEY. MUŞ:** BULANIK, 5 km to Arakonak village, roadside 39°04′09″N 42°07′49″E, 1602 m, on calcareous rock, 30.06.2015, leg. Kenan YAZICI. (KTUB–2426); **BURDUR:** ALTINYAYLA, Karanlıkdere canyon, 36°49′33″N 29°24′31.07″E, 1429 m, on calcareous rock, 23.08.2013, leg. Kenan YAZICI. (KTUB–2448).

REMARKS— Detailed descriptions of *Protoparmelia atriseda* are provided by Smith et al. (2009) and Poelt & Leuckert (1991). A similar species, *P. nephaea,* differs in its smaller thallus patches, association with *Rhizocarpon geographicum*

and *R. lecanorinum* (Poelt & Leuckert 1991), an absence of thalloconidia, differing K+ cortical and apothecial reactions, and disc colour.

Species associated with our specimens were *Candelariella vitellina*, *Montanelia sorediata*, and *Rhizocarpon geographicum*. Initially parasitic (especially on *R. geographicum* and *R. lecanorinum*), *P. atriseda* is later autonomous on well-lit upland or submontane hard siliceous rocks. Previously known from Europe (Belgium, Denmark, France, Poland) and North America, *P. atriseda* is new to Turkey and Asia.

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New *Bacidia, Opegrapha,* and *Rhizocarpon* records for Turkey and Asia

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Abstract — *Bacidia herbarum, Opegrapha dolomitica, Opegrapha saxigena,* and *Rhizocarpon ridescens* are newly recorded from Turkey. *Opegrapha dolomitica* and *O. saxigena* also represent new lichen records for Asia. Brief descriptions are provided for each species.

Key words—flora, Black Sea, Giresun

Introduction

In the last five years, lichenological investigations in Turkey have produced many new lichen records for the country (e.g. Öztürk & Güvenç 2010, Oran & Öztürk 2010, Arslan et al. 2011, Karagöz et al. 2011, Kınalıoğlu & Aptroot 2011, Şenkardeşler & Calba 2011, Vondrák et al. 2012, Aslan & Yazıcı 2013, Çobanoğlu et al. 2013, Yazıcı et al. 2013, Halıcı et al. 2014, Kocakaya et al. 2014). Despite the increase in the number of lichens recorded, additional study is needed in some regions where the lichen flora remains poorly known. Here we provide four additional lichen records for the Turkish lichen biota.

Materials & methods

The study material was collected during lichen-collecting excursions in the region Giresun in the north of Turkey. Specimens were deposited in the herbarium of the Biology Department, Faculty of Science and Arts, Giresun University, Giresun, Turkey (GUB). The collections were identified following routine microscopical techniques. Water, 10% potassium hydroxide (KOH), and Lugol's iodine (I) were used as mountants

for hand-cut anatomical sections that were examined under the light microscope. Ascospores were measured in water and KOH at 400× magnification.

Taxonomy

Bacidia herbarum (Stizenb.) Arnold, Flora 48: 596. 1865.

Thallus muscicolous, whitish grey, thin. Apothecia dark brown-black, scattered, 0.4–1 mm diam. Hymenium 45–55 µm tall, epihymenium fawn, hypothecium with upper part pale brownish-reddish. Ascospores 3–7- septate, 30–50 × 2–2.5 µm. Pycnidia absent. Thallus C–, K–, KC–, PD–.

Specimen examined: **TURKEY. Giresun**: Şebinkarahisar, N of Asarcık village, 40°25′11″N 38°23′33″E, 1856 m, on mosses, 26 Oct. 2014, leg. K.Kınalıoğlu (GUB 2378).

Remarks—For detailed descriptions of the species see Thomson (1997), Smith et al. (2009), and Dobson (2011). *Bacidia herbarum* is a rare boreal circumpolar species, growing on mosses, on calcareous turf in grassland or amongst limestone rocks, and on small perennial plants or plant debris, from sea level to 800 m (Thomson 1997, Smith et al. 2009, Dobson 2011). In Turkey, it has been collected only on mosses at high elevation.

Known from Asia, Europe, and North America (Thomson 1997, Smith et al. 2009); this is the first record of *B. herbarum* for Turkey.

Bacidia herbarum is similar to *B. bagliettoana,* which has black apothecia with a green epihymenium (Smith et al. 2009). The sizes of the apothecia, ascospores, and hymenium in the Turkish specimen are smaller than the sizes given by Thomson (1997; apothecia 0.4–1.5 mm diam, ascospores 30–60 × 1.5–3 µm, hymenium 55–60 µm), Smith et al. (2009; apothecia 0.3–0.7 mm. diam., ascospores 36–60 × 2–2.5 µm, hymenium 45–60 µm), and Dobson (2011; apothecia ≤0.7 mm diam., ascospores 30–50 × 2–3 µm, hymenium 45–60 µm). The Turkish collection also differs ecologically by growing on siliceous rock.

Opegrapha dolomitica (Arnold) Clauzade & Cl. Roux ex Torrente & Egea, Biblioth. Lichenol. 32: 146. 1989.

Thallus saxicolous, thin or immersed, cream. Apothecia black, scattered, 0.4–1.5 × 0.25–0.7 mm diam. Hymenium 90–120 µm tall, epihymenium pale brownish. Ascospores hyaline, 3-septate, 16–24 × 5–7µm, clavate, with a thin perispore. Thallus C–, K–, KC–, PD–, UV–.

Specimen examined: **TURKEY. Giresun**: Keşap, Değirmenağzı village, sea shore, 40°58′23″N 38°37′29″E, 2 m, on siliceous rock, 19 May 2015, leg. K.Kınalıoğlu (GUB 2379).

Remarks—For detailed descriptions of the species see Smith et al. (2009) and Dobson (2011). *Opegrapha dolomitica* is found on sheltered moist limestone or calcareous schists, the side of flints in limestone pavement, mortar, or

associated base-rich siliceous rock (Smith et al. 2009, Dobson 2011). In Turkey, we recorded it only from coastal siliceous rocks on the Black Sea shore.

Known from Europe (Smith et al. 2009); this is the first record of the species for Turkey and Asia.

Opegrapha dolomitica differs from *O. calcarea* by the K–, brown pigmentation of the apothecial tissues, longer ascospores, and the usually longitudinally furrowed or gnarled-subgyrose shape of the apothecium (Smith et al. 2009). The Turkish material of *O. dolomitica* differs from European specimens by having smaller apothecia and ascospores. In European collections, the apothecia are 0.5–3 × 0.16–0.35 mm, and the ascospores are 20–31 × 5-8 µm (Smith et al. 2009). The Turkish collection differs ecologically in occurring on siliceous rock at a coastal locality.

Opegrapha saxigena Taylor, Ann. Mag. Nat. Hist., Ser. 2, 13: 93. 1854.

Thallus saxicolous, thin, superficial, brownish or purplish-brown. Apothecia black, 0.5–1.1 × 0.18–0.4 mm diam. Hymenium 80–120 µm tall, epihymenium brown. Ascospores hyaline, 3-septate, 16.5–21 × 4–5 µm, narrowly ellipsoid or rarely lightly clavate. Thallus C–, K–, KC–, PD–, UV–.

Specimen examined: **TURKEY. Giresun**: SW of centre, Boztekke village, 40°55′05″N 38°18′31″E, 8 m, on siliceous rock, 10 Apr. 2010, leg. K.Kınalıoğlu (GUB 2380).

Remarks—For detailed descriptions of the species see Smith et al. (2009) and Dobson (2011). Elsewhere in its range *O. saxigena* grows on deeply shaded siliceous rock, particularly in old woodlands, rarely on smooth bark (e.g., *Ilex*), often forming extensive communities with *O. gyrocarpa* and *O. zonata* and locally frequent (Smith et al. 2009, Dobson 2011). In Turkey, our sample was collected from siliceous rock in partly shaded and damp hazelnut gardens. In accordance with the literature, our sample grew together with *O. zonata.*

Known from western Europe (Smith et al. 2009), this is the first record of *O. saxigena* for Turkey and Asia.

Opegrapha saxigena differs from *O. gyrocarpa* and *O. zonata* by the absence of soralia and the lack of lichen products (Smith et al. 2009). The apothecia and ascospores in the Turkish collection are almost the same size as given by Smith et al. (2009; apothecia 0.5–1.4 × 0.15–0.45 mm. diam, ascospores 15–22 × 4–6 µm) and Dobson (2011; apothecia ≤1 mm diam, ascospores 15–20 × 4–5 µm).

Rhizocarpon ridescens (Nyl.) Zahlbr., Nat. Pflanzenfam. 1(1*): 138. 1905.

Thallus saxicolous, areolate, areoles to 1.2 mm diam, roundish, strongly convex, dispersed, pale greenish-yellow, with granular soralia; prothallus black, medulla I+ blue. Apothecia absent. Medulla K–, PD+ yellow

Specimen examined: **TURKEY. Giresun**: Şebinkarahisar, between Asarcık village and Saplıca village, stream bank, 40°24′13″N 38°25′09″E, 1504 m, on iron-bearing siliceous rock, 26 Oct. 2014, leg. K.Kınalıoğlu (GUB 2381).

Remarks—For a detailed description of the species see Smith et al. (2009). *Rhizocarpon ridescens* grows on metal-rich siliceous rocks in montane to alpine localities (Wirth 1995) and is also reported from a south-facing metal-rich vertical siliceous crag at an elevation of 430 m in Scotland (Smith et al. (2009). In Turkey, *Rhizocarpon ridescens* was found on iron-bearing siliceous rock on a stream bank at an altitude of 1504 m, accompanied by *Rhizocarpon lecanorinum*, *Lecidea silacea*, and *Rhizocarpon oederi*.

Known from central Asia and Europe (Smith et al. 2009), this is the first record of the species for Turkey.

Rhizocarpon ridescens is distinguished from the other yellow *Rhizocarpon* species in having soredia, although some *Lecanora* species can be similar and the brown *R. furfurosum* has blastidia (Smith et al. 2009). The size of the areoles in the Turkish material is slightly larger than the size previously reported by Smith et al. (2009; soralia ≤1 mm diam.).

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Helicoma jianfenglingense sp. nov. and *Cubasina* and *Endophragmiella* species new to China

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Abstract — A new species, *Helicoma jianfenglingense,* is described and illustrated from specimens collected on dead branches in Hainan Province. It differs in conidial morphology from the other known *Helicoma* species. Descriptions and illustrations are provided of two other asexual fungi, *Endophragmiella albiziae* and *Cubasina albofusca*, which are recorded for the first time from China.

Key words — hyphomycetes, taxonomy

Introduction

The genus *Helicoma* was introduced by Corda (1837), with the type species *H. muelleri* Corda. The early concept of *Helicoma* was often confused with *Helicomyces* and *Helicosporium* for their similar helical conidia. Linder (1929), who treated 26 *Helicoma* species, characterized the genus as having thick-walled, non-hygroscopic, coiled conidia that distinguished it from *Helicomyces* and *Helicosporium* and other allied genera with hygroscopic conidia. Zhao et al. (2007) dealt with *Helicoma* and accepted 45 species. Since then, three additional *Helicoma* species have been described (Boonmee et al. 2014). A fungus with the morphological characteristics of *Helicoma* is proposed here as a new species.

In addition, two other anamorphic fungi, *Endophragmiella albiziae* and *Cubasina albofusca,* have been collected that represent new records for China. About 75 species have been accepted in *Endophragmiella* (Kirk et al. 2008) while *Cubasina* contains two species (Castañeda-Ruíz 1986, Marques et al. 2007).

Specimens were collected on decaying twigs and dead stems in the tropical forests from China and are deposited in the Herbarium, Department of Plant Pathology, Shandong

Agricultural University, Taian, China (HSAUP) and the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Helicoma jianfenglingense J.M. Gao & X.G. Zhang, sp. nov. FIG. 1

MycoBank MB 817482

Differs from most other *Helicoma* species by its semi-helicoid conidia.

Type: China. Hainan Province: Jianfengling National Forest Park, on dead stems of unidentified broadleaf tree, 20 Apr. 2015, J.M. Gao (**Holotype**, HSAUP H9713; **isotype**, HMAS 245603).

Etymology: in reference to the type locality.

FIG. 1. *Helicoma jianfenglingense* (holotype, HSAUP H9713). A. conidiophores, conidiogenous cells, and conidia. B. conidiophore and conidiogenous cell. C. conidia.

Colonies on natural substrate effuse, pale brown to brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of septate, smooth, branched hyphae. Conidiophores simple or rarely branched, erect, straight or slightly flexuous, dark brown, slightly paler in the distal part, cylindrical, smooth-walled, septate, 70–150 × 3–4 µm. Conidiogenous cells mono- or polyblastic, integrated, terminal or rarely intercalary, determinate, cylindrical, denticulate, smooth, sporogenous denticles pale brown, inconspicuous, cylindrical, 1–2 × 0.5–1 µm. Conidia dry, solitary, acropleurogenous, hyaline, semi-helicoid, coiled ¼–½ times, 5.5–13.5 µm in diam; smooth, conidial filament 4–5 µm wide, indistinctly 2–12-septate, rounded at the apex, with a distinctly darkened conidial scar.

Comments—*Helicoma jianfenglingense* differs from previously described species of *Helicoma* in the number of conidial coils. The semi-helicoid conidia of *H. jianfenglingense* are less coiled than those of other *Helicoma* species (coiled ½–4½ times; Zhao 2007). *Helicoma indicum* also has semi-helicoid conidia, but they are smaller, uniseptate, and coiled ½–¾ times, and the conidiophores are fasciculate to synnematous (Gawas & Bhat 2007).

Endophragmiella albiziae (M.B. Ellis) S. Hughes, New Zealand J. Bot. 17:146 (1979)
Fig. 2
≡ *Domingoella albiziae* M.B. Ellis, Mycol. Pap. 131: 3 (1972)

Colonies effuse, pale brown to brown, hairy or velvety. Mycelium partly superficial, partly immersed in the substratum, composed of septate, smooth, pale brown to dark brown, 1–9 µm thick hyphae. Conidiophores arising singly, terminally and laterally on the hyphae, straight or flexuous, subulate or cylindrical, septate, brown to dark blackish brown, paler towards the apex, with 0–9 terminal proliferations, 200–500 × 5–9 µm, sometimes swollen at the base. Conidiogenous cells monoblastic, terminal, brown, cylindrical. Conidia solitary, dry, formed first at the apex and then terminally on each successive percurrent proliferation, spherical, pale brown to brown, aseptate, smooth, thick-walled, 16–20 µm diam. with a short cylindrical pedicel at the base.

Specimen examined: **China. Yunnan Province**, tropical forest of Menglun, on dead stems of unidentified broadleaf tree, 19 Dec. 2014, J.M. Gao (HSAUP H9605).

Comments—The transfer of *Domingoella albiziae* to *Endophragmiella* by Hughes (1979) is currently accepted (Kirk 1985, Kirk et al. 2008, Seifert et al. 2011). The species is reported for the first time from China. The Chinese specimen closely matches the protologue description (Ellis 1972, as *D. albiziae*; Hughes 1979), except that the type specimen has slightly bigger conidia (16–22 µm diam).

Fig. 2. *Endophragmiella albiziae* (HSAUP H9605). A, D. conidiophores, conidiogenous cells, and conidia. B. conidiophore and conidiogenous cells. C. conidia.

Cubasina albofusca R.F. Castañeda, Deuteromyc. Cuba, Hyphomyc 4: 6 (1986) Fig. 3

Colonies on natural substrate effuse, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of septate, hyaline, smooth hyphae. Conidiophores mononematous, simple, distinct, erect, straight or

Fig. 3. *Cubasina albofusca* (HSAUP H9636). A, B. conidiophores, conidiogenous cells, and conidia. C. conidia.

slightly flexuous, geniculate, hyaline, unbranched, 30–120 × 3.5–7.0 μm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, hyaline. Conidia acrogenous, blastic, solitary, dictyoseptate, distinctly irregular, smooth, thick-walled, globose or subglobose, brown when mature, 20–30 × 15–25 μm.

Specimen examined: **CHINA. Yunnan Province**, tropical forest of Mengyang, on dead stems of unidentified broadleaf tree, 22 Dec. 2014, J.M. Gao (HSAUP H9636).

Comments—*Cubasina albofusca*, which was described from Cuba, is reported for the first time from China. The Chinese specimen closely matches the protologue description (Castañeda-Ruíz 1986), except that the type specimen has longer conidiophores (40–150 × 2–3.5 μm) and smaller acropleurogenous conidia (17–25 × 10–18 μm).

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Evidence for *Gymnosporangium atlanticum* in Europe

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Abstract — Specimens morphologically identical to *Gymnosporangium atlanticum* have been found in Spain at four different locations. We describe these findings and provide an accurate description and illustrations. DNA sequences from these specimens are closely enough related to those from *G. sabinae* that the two species cannot be discriminated with the three DNA markers employed.

Key words — teliospores, *Juniperus*, Morocco, Mediterranean, ITS, TEF1α

Introduction

The genus *Gymnosporangium* R. Hedw. ex DC. (*Pucciniales*) is widespread in temperate regions of the Northern Hemisphere. Its species are obligate parasites of vascular plants, with a complex life cycle that includes several states with different spore types. Most of these taxa are heteroecious, this is, they alternate different biological states in two distinct hosts: the annual aecial state on dicotyledonous host plants (mainly *Rosaceae*), and a perennial telial state on gymnosperms (especially *Juniperus*).

Gymnosporangium atlanticum was first described from specimens in the telial state found on *Juniperus phoenicea* L. growing in dunes at Mehedya, on the Atlantic coast of Morocco (Guyot & Malençon 1957). This species was reported again from Morocco (Rieuf 1969), on *J. phoenicea* and *Juniperus* sp. In his monograph on *Gymnosporangium,* Kern (1973) considered *G. atlanticum* an exclusively African species. To our knowledge, there seem to be no other published records of this taxon except for one citation from China (Zhao &

Zhuang 2006), where specimens on *Juniperus sabina* L. were identified as *G. atlanticum* based on Kern's description.

There is a report by Llimona & Vila (1998) mentioning the occurrence of telia of *G. atlanticum* growing on *Juniperus thurifera* L. and *J. phoenicea* in Retuerta de Pina (Zaragoza, Spain). This report refers to several specimens in the telial state collected by J. Blasco-Zumeta in 1989, 1990, and 1993, which were morphologically identified by one of us (I. Llorens) as *G. atlanticum* and which also match samples found by Llorens in Punta de la Móra (Tarragona, Spain) in 1987, 1989, and 1990 on *Juniperus phoenicea* subsp. *turbinata* (Guss.) Nyman (as "*J. phoenicea* subsp. *lycia*") in sandy soil near sea level. In 2014, 2105, and 2016 new specimens were located in Punta de la Móra on the same host, and in 2016 specimens on *J. phoenicea* were found in two new sites in Tarragona.

The purpose of the present work is to provide morphological and molecular data from these unpublished European collections in order to support future diagnostic and phylogenetic studies in *Gymnosporangium*.

Materials & methods

A piece of the holotype of *G. atlanticum* stored in the herbarium of the Université de Montpelier II, France (MPU), was kindly loaned by Dr. Jean-Michel Bellanger and Dr. Caroline Loup. The Spanish material examined from years 1987 to 1990 is stored in the herbarium CeDoc de Biodiversitat Vegetal, University of Barcelona, Spain (BCN) and the 2016 specimens from La Sénia are in P. Prats personal herbarium (PPR); the remaining specimens are kept at J.L. Fernández personal herbarium (JLF) and are available on request. Microscopic examination was conducted using a Leica

Table 1. Spanish *Gymnosporangium* specimens from *Juniperus* and *Pyrus* hosts used in DNA sequencing, with GenBank accession numbers.

Taxon	Host	Locality	Herb. JLF	LSU	ITS	TEF1α
G. atlanticum	*J. phoenicea* subsp. *turbinata*	Tarragona	20140331-6	–	KM403109	–
			20140331-7	–	KP261044	–
			20140331-10	KM403111	KM403108	–
			20150227-M1	KT160254	KT160250	KT160255
			20150227-M2	KT160253	KT160251	KT160256
G. sabinae	*J. oxycedrus*	Teruel	20140330-3 M2	–	KM403110	KM403112
			20150325-2 M2	–	KT160252	–
G. sabinae	*P. communis*	Teruel	20140923-H2	–	KP261039	–

1000 LED microscope equipped with a EC3 camera; samples from all specimens were mounted in water and additionally in 3% KOH for the holotype and the BCN herbarium material. The teliospores were measured with the Piximètre 5.5 software. Specimens were identified based on the original protologue by Guyot & Malençon and the direct examination of the holotype.

DNA was extracted from eight dry specimens (Table 1), and the polymerase chain reaction (PCR) was performed according to Alvarado et al. (2012). Primers ITS1F and ITS4 (White et al. 1990, Gardes & Bruns 1993) were employed to amplify the ITS region, while LR0R and LR5 (Vilgalys & Hester 1990) were used for the 28S nLSU region, and EF1-983F and EF1-1567R (Rehner & Buckley 2005) for the translation elongation factor gene (TEF1α). PCR products were checked in 1% agarose gels, and positive reactions were sequenced with the same primers. Chromatograms were checked for putative reading errors, which were corrected.

Taxonomy

Gymnosporangium atlanticum Guyot & Malençon, Trav. Inst. Scient. Chérifien Sér. Bot. 11:15, 1957. Pls 1–3

Telia located on fusiform swellings, in branches of various sizes, erumpent through the bark of the host, also on green stems, often confluent, pulvinate, hemispheric 1.5–3 mm in diameter or elongated ≤2 × 5 mm, 1–2.5 mm high, dark brown, swelling slightly when moist. Teliospores 2-celled, ellipsoidal, apex rounded to conical, base narrowed or sub-rounded, with lipid droplets when young, pedicel cylindrical, hyaline. There are two types of teliospores: the most abundant are slender, constricted at the septum, with fairly homogeneous wall thickness, although often thickened at the apex, light colored, (41–)48.4–48.6(–56) × (16.5–)21.3–21.5(–26) µm, Qm = 2.3; the less abundant teliospores are rounded, slightly or not at all constricted at the septum, provided with a darker and often thinner wall sometimes thickened near the septum, (38–)45.7–46.4(–54) × (22.5–)27.1–27.5(–32) µm, Qm = 1.7; measures including the two types of teliospores are (40.5–)48.1–48.3(–56) × (16–)22–22.1(–28) µm, Qm = 2.2. Wall thickness (from both types of spores): 1.2–3.9 µm. There are intermediate forms between the two main ones already described and also (exceptionally) teliospores with 1 or 3 cells. Germ pores are readily visible; (2–)3–4(–rarely 5) are usually arranged in a more or less narrow band near the septum in both cells, often with 1(–2) additional pores located near the apex or base of the higher or lower cells, respectively. Basidiospores ovoid in front view, broadly ellipsoidal with a straight side or kidney-shaped in side view, apiculate, 15–18 × 9–11 µm, Qm = 1.6.

Ecology & distribution—According to quotes from Morocco, China and Spain, this species develops the telial state in branches of *Juniperus* sect. *Sabina*. In Tarragona, it was found on *J. phoenicea* subsp. *turbinata* in a coastal dune area

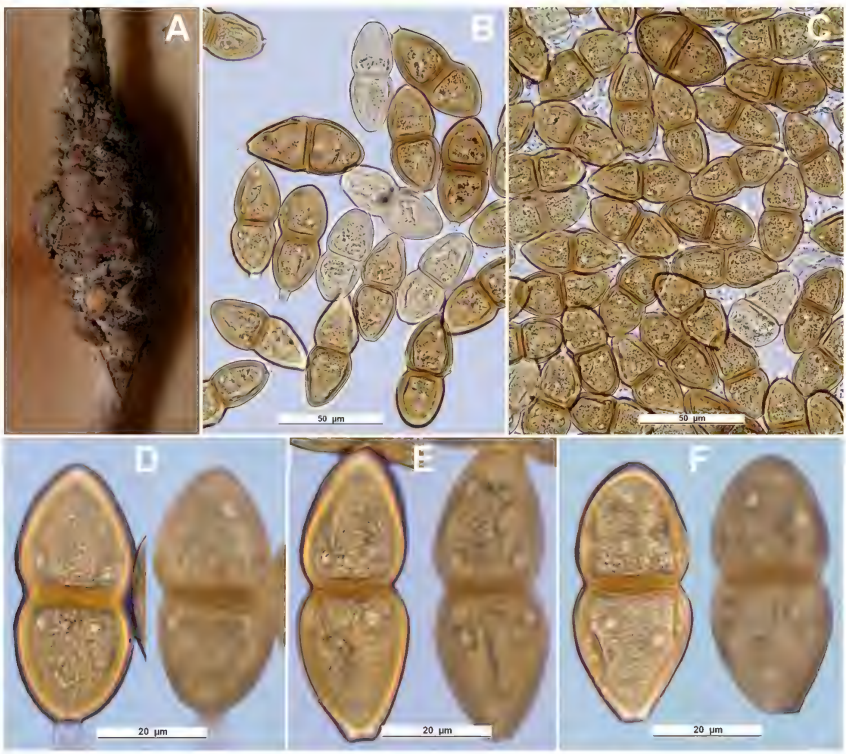

Plate 1. *Gymnosporangium atlanticum*, holotype (MPUC03909). A: dried telia. B, C: teliospores of two types. D–F: arrangement of the germ pores; 4 pores per cell in bands near the septum, with additional pores toward the end of both cells. (A, photo by J-M. Bellanger; B–F, photos by J.L. Fernández).

and on *J. phoenicea* in mountain zones with *Pinus* sp. also present; in Retuerta de Pina, Zaragoza, the hosts were *J. phoenicea* and *J. thurifera* in a Mediterranean steppe habitat. The 24-II-1990 collection from Retuerta de Pina included telia growing on a host galbulus (an unusual substrate for *Gymnosporangium*) but unfortunately the infected galbulus was not conserved in the herbarium specimen. The aecial state of *G. atlanticum* is thus far unknown.

Specimens examined —

Gymnosporangium atlanticum: **MOROCCO**: Mehedya, on *Juniperus phoenicea*, 19-II-1939, leg. Ch. Rungs (holotype MPUC03909). **SPAIN**: **Tarragona**, Punta de la Móra, 0–25 m asl, on *Juniperus phoenicea* subsp. *turbinata* (as "*Juniperus phoenicea* subsp. *lycia*"), 20-II-1987, leg. P. Navarro (BCN-myc ILL 1331); leg. A. Gómez (BCN-myc ILL 1352); leg. M. Tabares (BCN-myc ILL 1353); leg. A. Gómez, P. Navarro et al. (BCN-myc ILL 1377); 20-IV-1989, leg. X. Llimona & N. Pàmies (BCN-myc ILL 1498); 2–4 m asl on *Juniperus phoenicea* subsp. *turbinata*, 31-III-2014, leg. J. Castillo & P. Prats

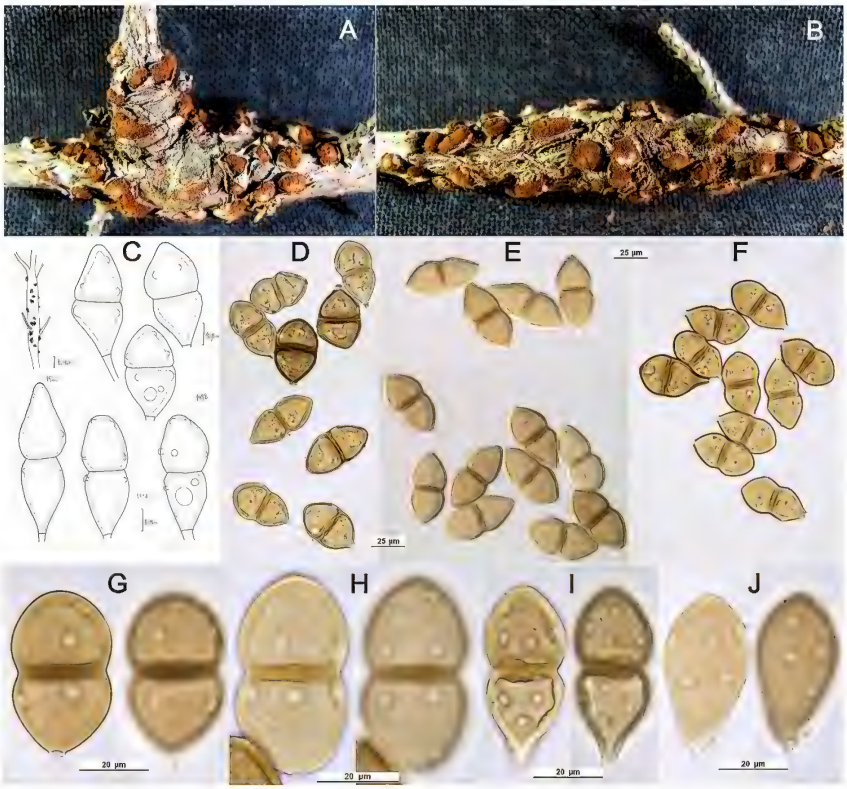

Plate 2. *Gymnosporangium atlanticum,* 1987–1990 collections. A, B: dried telia. C: telia and teliospores (drawing by I. Llorens). D–F: teliospores of two types. G–J: variation in teliospore germ pores (G: 4 pores per cell in bands near the septum; H: bands with 4 and 5 pores, plus 1 per cell towards the apex and base respectively; I: 8 pores in upper cell and 7 in lower cell; J: teliospore 1-celled with 10 pores apparently on 5 parallel planes). (Photos by J.L. Fernández).

(JLF 20140331-3); (JLF 20140331-4); (JLF 20140331-5); (JLF 20140331-6; GenBank KM403109); (JLF 20140331-7; GenBank KP261044); (JLF 20140331-8); (JLF 20140331-9); (JLF 20140331-10; GenBank KM403108, KM403111); (JLF 20140331-11); 04-IV-2014, leg. P. Prats (JLF 20140404-1); (JLF 20140404-2); 27-II-2015, leg. J. Castillo & P. Prats (JLF 20150227-M1; GenBank KT160250, KT160254, KT160255); (JLF 20150227-M2; GenBank KT160251, KT160253, KT160256); (JLF 20150227-M3); (JLF 20150227-M6); (JLF 20150227-M7); (JLF 20150227-M8); (JLF 20150227-M9); (JLF 20150227-M10); 19-III-2015, leg. P. Prats (JLF 20150319-1); Cornudella de Monsant, 850 m asl, on *Juniperus phoenicea*, 27-III-2016, leg. P. Prats (JLF 20160327); La Sénia, 1110 m asl, on *Juniperus phoenicea*, leg. P. Prats (PPR 9584M5). **Zaragoza**, Retuerta de Pina, 390–395 m asl, on *Juniperus thurifera,* 14-V-1989, leg. J. Blasco-Zumeta (BCN-myc ILL 1508); 24-II-1990, leg. J. Blasco-Zumeta (BCN-myc ILL 1557; on *J. phoenicea,* 04-III-1990, leg. J. Blasco-Zumeta; (BCN-myc ILL 1560).

Plate 3. *Gymnosporangium atlanticum,* 2014–2015 collections. A–C: telia (A: moist; B, C: dry). D–F: teliospores of two types (E: germinating teliospore; F: basidium and basidiospore). G–I: germ pores (G: 4 pores per cell in bands near the septum; H, I: with additional pores towards the end of both cells). (A–C, photos by P. Prats; D–I, photos by J.L. Fernández).

Gymnosporangium sabinae: **SPAIN**: **Teruel**, Beceite, Barranco Comellasos, 595 m asl, on *Juniperus oxycedrus* L., 30-III-2014, leg. J.L. Fernández (JLF 20140330-3 M2; GenBank KM403110, KM403112); 25-III-2015, leg. J.L. Fernández (JLF 20150325-2 M1); (JLF 20150325-2 M2; GenBank KT160252); (JLF 20150325-2 M3); (JLF 20150325-3 M1); (JLF 20150325-3 M2); (JLF 20150325-3 M3); (JLF 20150325-3 M4); (JLF 20150325-3 M5); (JLF 20150325-3 M6); (JLF 20150325-3 M7); Parrizal 30, 579 m asl, on *Pyrus communis* L., 23-IX-2014, leg. J.L. Fernández (JLF 20140923-H2; GenBank KP261039). **Baleares**, Mallorca, Sóller, on *Juniperus phoenicea* subsp. *turbinata*, 18-III-2015, leg. J. Bibiloni (JLF 20150318).

Discussion

Morphological and ecological features of the Spanish collections match those of the protologue of *Gymnosporangium atlanticum* as well as our own observations of the holotype. We believe that all these specimens represent a single taxon, which we regard as the first report of *G. atlanticum* in Spain and Europe.

Three other *Gymnosporangium* species produce teliospores with more than two pores per cell: *G. multiporum* F. Kern from USA teliospores have 5–7 scattered pores, but no special pattern can be observed (Kern 1909), while *G. gjaerumii* Korbonsk. & Azbukina from Asia teliospores have 4 pores located more or less close to the septum (Azbukina 1997). Both *G. multiporum* and *G. gjaerumii* develop telia on juniper leaves while the telia of *G. atlanticum* occur in branches. Finally, *G. taianum* F. Kern from Asia resembles *G. atlanticum* in the number and distribution of the teliospore pores, but its host is *Cupressus* (Kern 1964).

We hope that our DNA sequences, the first molecular data from morphologically validated specimens of *G. atlanticum,* will help identify its aecial state in the future. A BLAST search of the ITS region from *G. atlanticum* revealed a 99% identity with several sequences identified as *G. sabinae* (Dicks.) G. Winter from an unpublished work by Filipp & Spornberger (seq. KF925316–KF925321) but only 86% identity with a sequence (KJ720183) from

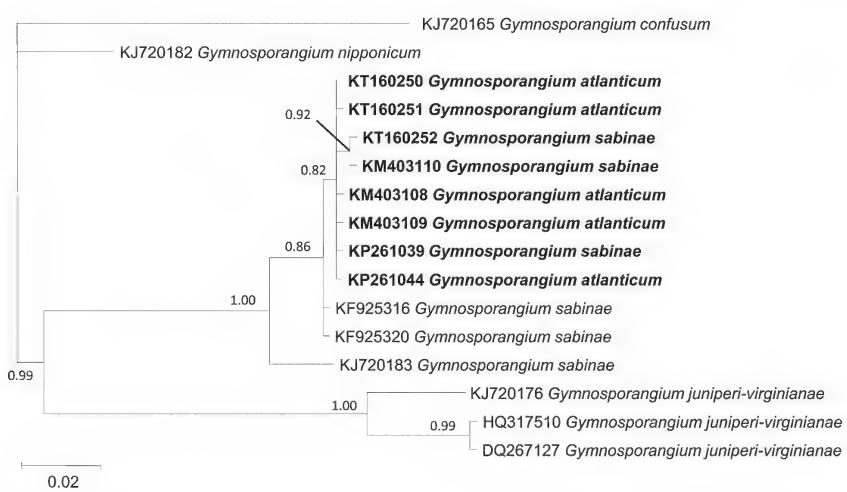

Plate 4. Consensus phylogram constructed in MrBayes 3.1 from an alignment of the ITS sequences produced with those most closely related in public databases. Nodes with >0.80 PP support are annotated. Sequences highlighted in bold have been produced in the present work.

Plate 5. *Gymnosporangium sabinae*. Top: moist telia. Bottom: teliospores of two types, and basidiospores (mostly out of focus). (Photos by J.L. Fernández).

another specimen of *G. sabinae* from Novick et al. (unpubl.) (Plate 4). LSU data revealed subtle differences with a sequence from Novick et al. (unpubl.), and other *G. sabinae* sequences from a Turkish specimen found on *Pyrus* sp. (Dervis et al. 2010). TEF1α sequences found no close BLAST match, but only a 87% similarity with a *G. clavariiforme* sequence (DQ925242) from van der Merwe et al. (2007). Attempts to obtain DNA sequences from the *G. atlanticum* holotype and the specimens collected from 1987 to 1990 failed.

Our comparison of sequences from specimens matching our own concept of *G. sabinae* with those of *G. atlanticum* revealed almost no ITS differences, with only a few positions exhibiting heteromorphisms or ambiguous base readings. LSU was entirely identical between our samples of *G. sabinae* and *G. atlanticum*, while TEF1α presented only scattered heteromorphic sites or

ambiguous reads. Unfortunately, the RPB2 gene could not be sequenced with primers bRPB2-6F2 and fRPB2-7cR (Matheny et al. 2007).

These sequence analyses suggest that *G. atlanticum* and *G. sabinae* are extremely closely related, possibly indicating a recent speciation event. To test this hypothesis, more DNA markers with higher phylogenetic signal should be studied. Spanish specimens that might represent a different species from those occurring in Morocco should be examined first before drawing any taxonomic conclusion.

Gymnosporangium atlanticum and *G. sabinae* share similar ecologies: *Juniperus phoenicea*, *J. phoenicea* subsp. *turbinata*, *J. thurifera*, and *J. sabina* are hosts of the telial states in both. Morphologically, however, *G. sabinae* (Plate 5) and *G. atlanticum* are very different. The telia differ largely in shape and size: in *G. sabinae* they are conic laterally compressed or tongue-shaped and ≤10(–15) mm high when moist. Most *Gymnosporangium* species (possibly all) produce two distinct kinds of teliospores that differ more or less in shape and in wall color (Kern 1973). In *G. sabinae*, unlike *G. atlanticum*, the slender and light colored teliospores usually have thinner walls than the rounded and dark colored teliospores. The teliospores of *G. sabinae* are only slightly constricted at the septum and have only two germ pores per cell near the septum, while the teliospores of *G. atlanticum* are clearly constricted at septum and have up to 6 germ pores per cell with different arrangement.

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Asterolibertia moquileae comb. nov. on *Licania tomentosa* from Brazil

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Abstract — Two asterinaceous fungi, *Cirsosia moquileae* and *Wardina moquileae*, described on *Licania tomentosa* from Brazil, were determined to be conspecific by examination of their type specimens. A new combination, *Asterolibertia moquileae*, is proposed based on *Cirsosia moquileae*, with *Wardina moquileae* as a heterotypic synonym.

Key words — *Ascomycota*, *Asterinaceae*, systematics

Introduction

The genera *Wardina* G. Arnaud and *Asterolibertia* G. Arnaud were described in 1918, separated by the artificial criterion of presence or absence of pseudoparaphyses. The type of *Asterolibertia*, *A. couepiae* (Henn.) G. Arnaud, was masterfully illustrated by Arnaud (1918) showing dimidiate-scutellar, orbicular ascomata with stellar dehiscence, radiate upper wall and mycelium with intercalary hyphopodia (appressoria). Müller & Arx (1962) considered the type of the genus *Wardina*, *W. myocoproides* (Sacc. & Berl.) G. Arnaud, to be an *Asterolibertia* species, *A. myocoproides* (Sacc. & Berl.) Arx. They therefore treated *Wardina* (together with *Steyaertia* Bat. & H. Maia) as synonyms of *Asterolibertia*.

Batista & Maia (1960a,b) recorded *Cirsosia moquileae* and *Wardina moquileae* on leaves of *Moquilea tomentosa* Benth. [≡ *Licania tomentosa* (Benth.) Fritsch] (*Chrysobalanaceae*) in the State of Pernambuco, Brazil. The type specimens of both species were examined at URM herbarium and found to be conspecific. Both names were published in 1960, but *Cirsosia moquileae* (Batista & Maia 1960a; = Publ. Inst. Micol. Univ. Recife 225) has priority over *Wardina moquileae* (Batista & Maia 1960b; = Publ. Inst. Micol. Univ. Recife 230). The genus *Cirsosia* is distinguished from *Wardina*/*Asterolibertia* by possessing linear ascomata (Arnaud 1918, Müller & Arx 1962, Arx & Müller 1975, Bezerra 2004, Kirk et al. 2008, Hosagoudar 2010). However, *C. moquileae* was described by Batista as having orbicular ascomata, and this was confirmed by our examination of the type material.

The fungus on leaves of *Licania tomentosa*, referred to in the literature as *Cirsosia moquileae* and *Wardina moquileae*, cannot sensibly be retained in either of those genera. As mentioned above, its orbicular ascomata are incompatible with *Cirsosia,* and the genus *Wardina* is now treated as a synonym of *Asterolibertia* (Müller & Arx 1962, Bezerra 2004, Kirk et al. 2008, Hosagoudar 2010). Based on revision of the *C. moquileae* and *W. moquileae* types and other specimens from Amapá and Pernambuco deposited in URM herbarium, complemented by analysis of the literature and examination of fresh specimens collected in the State of Bahia, Brazil, we redescribe the species and transfer it to *Asterolibertia*.

Materials & methods

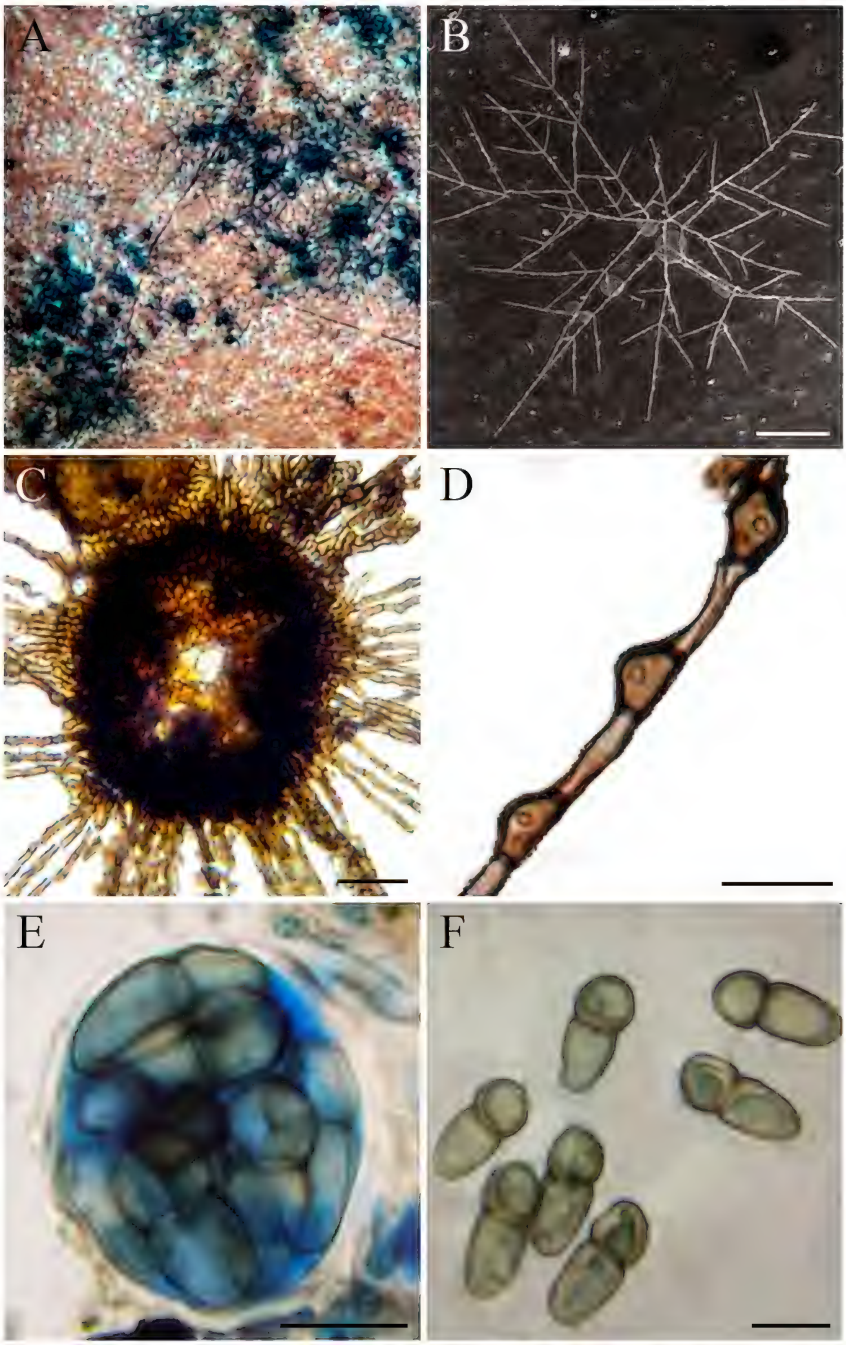
Leaves of *Licania tomentosa* parasitised by an epiphytic, superficial, black fungus were collected in the municipalities of Ilhéus and Itabuna and studied microscopically in the Plant Pathology Laboratory of the Universidade Estadual de Santa Cruz (UESC), Ilhéus, Bahia, Brazil. Slides were made with lactophenol cotton-blue and the structures were characterized and photographed under light and scanning electric microscopes. Species identification was accomplished based on the publications of Arnaud (1918), Hansford (1949), Müller & Arx (1962), Luttrell (1973), Arx & Müller (1975), Hosagoudar & Abraham (1997), and Hosagoudar (2010). The new specimens were conserved in the Herbarium, Centro de Pesquisas do Cacau, Itabuna, Bahia, Brazil (CEPEC-Fungi).

Taxonomy

Asterolibertia moquileae (Bat. & H. Maia) J.L. Bezerra, Firmino, S.P.B Araújo & Jad. Pereira, **comb. nov.** Figs 1, 2

MycoBank MB805756

Fig. 1 *Asterolibertia moquileae* (CEPEC-Fungi 2387). A. colonies on leaves of *Licania tomentosa*. B. superficial mycelium. C. ascoma with stellar dehiscence. D. hyphopodia intercalary, noduliform. E. bitunicate ascus. F. 1-septate mature ascospores. Bars: B = 200 µm; C = 50 µm; D = 20 µm; E, F = 10 µm.


A
B
C
D
E
F

≡ *Cirsosia moquileae* Bat. & H. Maia, Revista Biol. (Lisbon) 2(2): 121. 1960.
= *Wardina moquileae* Bat., Ann. Hist.-Nat. Mus. Natl. Hung. 52: 115. 1960.

Sexual morph: Colonies generally epiphyllous, rarely hypophyllous, black, flat, subcircular to irregular, isolated to confluent, 2.5–7 mm diam. Mycelium superficial, formed by dark brown, septate, straight to sub-straight, branched, anastomosed (teleomorphic) hyphae 15–22 × 4.5–5 µm. Hyphopodia (appressoria) intercalary, noduliform, unicellular, 10 × 7.5–10 µm. Ascomata tyriothecium-like, orbicular, applanate to dimidiate, black, opening by stellar to irregular dehiscence with fimbriate margins, 112.5–252 µm diam.; upper wall formed by rectangular, radiate cells. Asci subglobose, 8-spored, bitunicate, sessile, parallel arranged in the hymenium, 28–42 × 24–39 µm; pseudoparaphyses filamentous, simple or branched, embedded in a gelatinous matrix. Ascospores conglobate, brown at maturity, 1-septate, constricted at the septum, smooth, oblong, rounded at the ends, 21–23.5 × 5–9 µm with the upper cell broader than the lower.

Asexual morph: Pycnothyria numerous, circular, dimidiate, fringed at the borders, smaller than the ascomata with a central ostiole. Conidiogenous cells monoblastic, formed in the inner layer of the scutellum. Conidia 1–2 cells, ellipsoid, elongate, hyaline to olivaceous, 24–26 × 6–7 µm.

Specimens examined — **BRAZIL. Amapá**: Macapá, Serra do Navio, on leaves of *Licania tomentosa*, 22.VIII.1961, J.A. Lima (URM 28819, as *W. moquileae*). **Bahia**: Ilhéus, Campus da UESC, 14°47′46″S 39°10′28″W, on leaves of *L. tomentosa*, 26.VIII.2010, S.P.B. Araújo & J.L. Bezerra (CEPEC-Fungi 2219); Ilhéus, CEPLAC/SUEBA, 14°47′7″S 39°13′22″W, on leaves of *L. tomentosa*, 10.XI.2012, S.P.B. Araújo & J.L. Bezerra (CEPEC-Fungi 2387). **Pernambuco**: Vitória de Santo Antão, on leaves of *L. tomentosa*, 2.I.1958, A.C. Batista (URM 12570, holotype of *Wardina moquileae*); Paudalho, Chã de Capoeira, 18.IV.1959, O. Soares (URM 16146, as *C. moquileae*); Recife, Casaforte, on leaves of *L. tomentosa*, 22.IV.1956, S.J. da Silveira (URM 5470, holotype of *Cirsosia moquileae*); 22.IV.1956, S.J. da Silveira (URM 5471, 5471A, as *C. moquileae*); Recife, Dois Irmãos Ecological Reservation, on leaves of *L. tomentosa*, 3.IV.1960, J.L. Bezerra (URM 19795, as *W. moquileae*); 18.V.1966, J.L. Bezerra (URM 57001, as *W. moquileae*); 6.IX.1969, J.L. Bezerra (URM 71036, as *W. moquileae*); 18.IX.1969, J.L. Bezerra (URM 71041, as *W. moquileae*).

Notes: Seven species of *Asterolibertia* have been reported in association with chrysobalanaceous hosts: *Asterolibertia couepiae* on living leaves of *Couepia grandiflora* (Mart. & Zucc.) Benth. ex Hook. f. from Brazil; *A. nodulifera* (Syd. & P. Syd.) T.A. Hofmann on living leaves of *Angelesia splendens* Korth. from

Fig. 2 *Asterolibertia moquileae* (CEPEC-Fungi 2387). A, B. pycnothyria showing radiate wall and ostiole. C. detail of ostiole. D, E. hyphopodia intercalary. F. conidium. Bars: A, B = 50 µm; D = 20 µm; C, E, F = 10 µm.

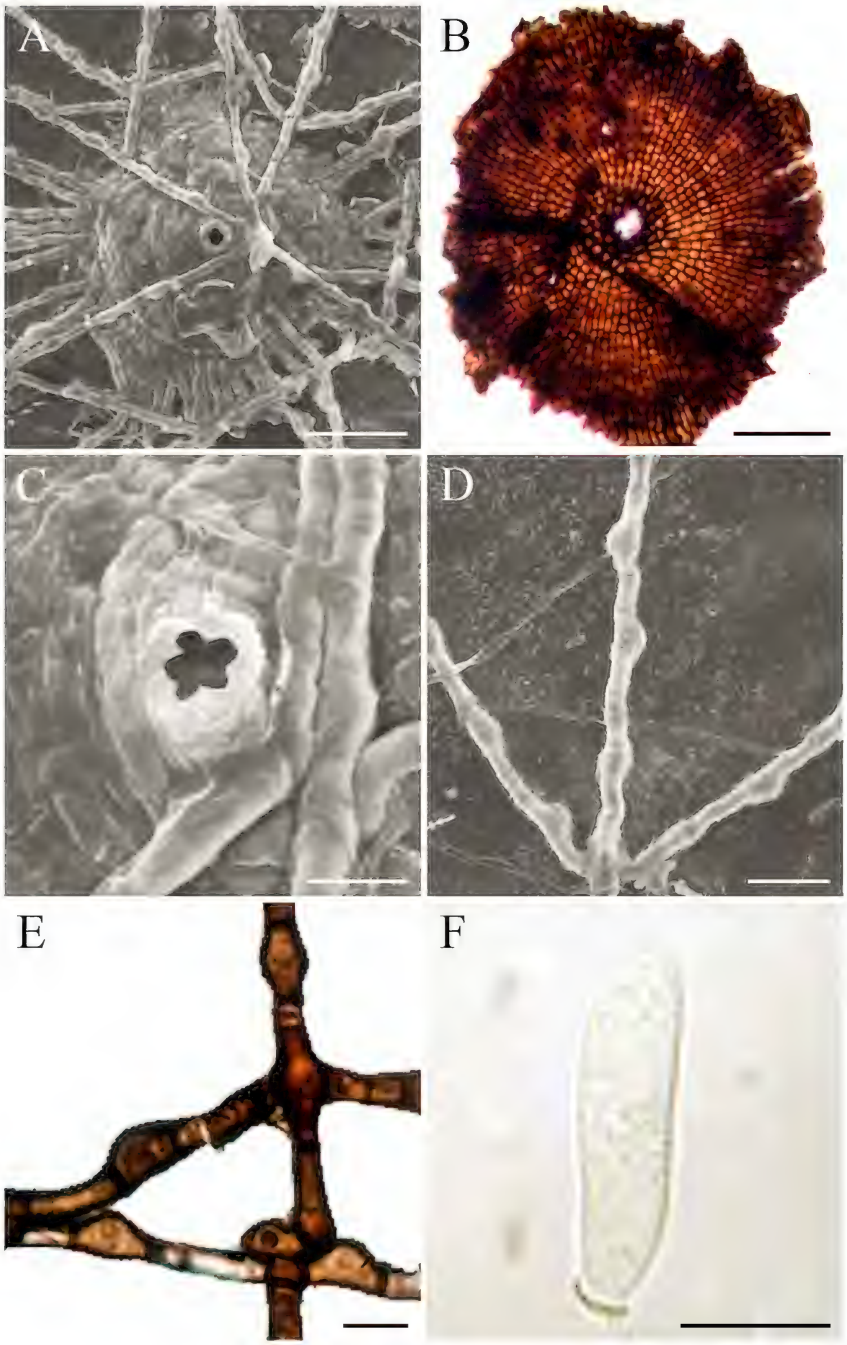

A
B
C
D
E
F

Table 1. Biometric data of *Asterolibertia* species on *Chrysobalanaceae*.

Species	Ascomata (µm)	Hyphae (µm)	Appressoria (µm)	Asci (µm)	Ascospores (µm)
A. couepiae	150–200	6–8	—	30–35 × 26–32	16–24 × 8–13
A. licaniae	≤450 × 300	6–9	7–13 × 9–13	—	30–33 × 18–20
A. licaniicola	170	4–5	9–11 × 6–7	—	24–28 × 12–15
A. moquileae	112.5–252	4.5–5	15–22 × 4.5–5	28–42 × 24–39	21–23 × 5–9
A. nodulifera	320–420	4.5–7	9–13 × 8–12	33–36 × 13–15	33–36 × 13–16
A. parinarii	130–160	3–4.5	6.5–7.5 × 5–6	30–38 × 25–35	18–22.5 × 5–6
A. peruviana	200	4–6	4–6 diam.	—	17 × 8
A. schroeteri	220–300	6–8	10–13 diam.	60–70 × 42–46	38–42 × 11–13

Philippines; *A. licaniae* (Cooke) Hansf. and *A. licaniicola* Hansf. on living leaves of *Licania* sp. from Brazil; *A. parinarii* (Syd.) Hansf. on living leaves of *Parinari subcordata* Oliv. [= *P. congensis* Didr.] from Congo; *A. peruviana* Hansf. on living leaves of *Licania macrophylla* Benth. from Brazil; and *A. schroeteri* (Rehm) Arx on living leaves of *Chrysobalanus icaco* L. from West Indies (Arnaud 1918; Hansford 1947, 1949, 1955; Müller & Arx 1962; Hosagoudar 2010; Hofmann & Piepenbring 2014; Farr & Rossman 2015).

Asterolibertia moquileae differs from *A. couepiae* by its subglobose to oblong asci; from *A. nodulifera* by its larger thyriothecia and ascospores, smaller appressoria, echinulate ascospores and lack of pseudoparaphyses; from *A. licaniae* by its larger thyriothecia, hyphae and ascospores, smaller appressoria and lack of paraphyses; from *A. licaniicola* by its larger ascospores and smaller appressoria; from *A. parinarii* by its smaller appressoria; from *A. peruviana* by its narrower appressoria without any lateral protuberance and smaller ascospores; and from *A. schroeteri* by its larger hyphae, asci and ascospores, smaller appressoria and lack of paraphyses (Arnaud 1918; Hansford 1947, 1949, 1955; Müller & Arx 1962; Hofmann & Piepenbring 2014), as shown in Table 1. There are no other *Asterolibertia* species reported on *L. tomentosa*. Pycnothyria were observed in our material, but following the current application of 'One fungus/one name' no separate name is proposed for this morph.

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Gymnosporangium huanglongense sp. nov. from western China

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Abstract — A novel rust species, *Gymnosporangium huanglongense,* was detected on *Juniperus przewalskii* in China. This species was characterized by the basal cell of its two-celled teliospores possessing two pores near the septum, and the distal cell possessing either two pores near the septum or occasionally an apical pore and one pore near the septum. It was also separated from other *Gymnosporangium* species based on analyses of internal transcribed spacer region and LSU rDNA partial gene sequences.

Key words — *Pucciniales,* Qilian Mountains, taxonomy

Introduction

The genus *Gymnosporangium* was validated by de Candolle in the Flore Française in 1805, based on a manuscript by R. Hedwig, with *G. fuscum* DC. on *Juniperus sabina* L. as the type species (Kern 1973). *Gymnosporangium* species are mainly distributed in the northern hemisphere. Kern (1973) reported 57 species, and four additional species have subsequently been described (Azbukina 1997, Zhao & Zhuang 2007, Yun et al. 2009). Eighteen species have been recorded from China: 14 with the telial stage on *Juniperus,* two with the telial stage on *Cupressus,* and two with only the aecial stage (Deng 1963, Tai 1979; Wang & Guo 1985; Zhao & Jiang 1986; Cao & Li 1999; Zhuang 2005, 2012; Zhao & Zhuang 2007).

During our investigation of tree diseases in western China, we found a telial stage of *Gymnosporangium* species on *Juniperus przewalskii* Kom., an endemic

TABLE 1. *Gymnosporangium* species and GenBank accession numbers used in this study.

SPECIES	VOUCHER*	GENBANK — ACCESSION NO.	
		ITS	LSU
G. huanglongense	**BJFC-R01984**	**KT719167**	**KT719161**
	BJFC-R01985	**KT719168**	**KT719162**
G. amelanchieris E. Fisch. ex F. Kern	20140331-1 M1-M3[a]	KM48[6]547b	—
G. asiaticum Miyabe ex G. Yamada	BJFC-R01834	KR814568	KT719165
	BJFC-R01835	KR814569	KT719166
	HKFRI 1974	—	FJ848741[b]
	HKFRI 1976	—	FJ848743[b]
G. clavariiforme (Wulfen) DC.	ML 841[a]	—	AF426[2]11b
	BPI 880006	—	HM114220[b]
G. clavipes Cooke & Peck	DAOM 234635	HQ317507[b]	—
G. confusum Plowr.	BPI 879272	—	GU058011[b]
	BPI 880005	—	HM114219[b]
G. cornutum Arthur ex F. Kern	HKFRI 2105	—	FJ848766[b]
	WM 1093	—	AF426210[b]
G. fusisporum E. Fisch.	HMAS 52880	—	KJ720172[b]
G. globosum (Farl.) Farl.	DAOM 234634	HQ3175[0]6b	—
	DAOM 234636	HQ317511[b]	—
G. gracile Pat.	20140326-1-GR-P25[a]	KM4865[4]2b	—
	20140529-1a[a]	KM4865[4]3b	—
G. japonicum Dietel & P. Syd.	HKFRI 1992	—	FJ848755[b]
	HKFRI 1993	—	FJ848756[b]
G. juniperi-virginianae Schwein.	DAOM 234434	HQ317510[b]	—
	PBM 2530	DQ2671[2]7b	—
	TDB1345[a]	—	AF5[2]2167b
	BPI 871103	—	DQ354547[b]
G. monticola H.Y. Yun	HKFRI 1984	—	FJ848770[b]
	HKFRI 1985	—	FJ848771[b]
G. nidus-avis Thaxt.	RSP 05-29[a]	—	KJ720[1]81b
G. sabinae (Dicks.) G. Winter	BG5[a]	KF925[3]20b	—
	BG6[a]	KF9253[2]1b	—
	WM 1347	—	AF4262[0]9b
	BPI 880007	—	HM114221[b]
G. unicorne H.Y. Yun	HKFRI 1971	—	FJ848767[b]
	HKFRI 1972	—	FJ848768[b]
G. yamadae Miyabe ex G. Yamada	BJFC-R01822	KR814566	KT719163
	BJFC-R01823	KR814567	KT719164
	HKFRI 1998	—	FJ848761[b]
	HKFRI 2007	—	FJ848765[b]
Puccinia graminis Pers.	K(M) 92038	AF4680[4]4b	—
	ECS[a]	—	AF5221[7]7b

* BJFC: Museum of Beijing Forestry University, Beijing, China; HKFRI: Herbarium of Korea Forest Research Institute, Seoul, Korea; DAOM: Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada; PBM: Department of Pharmaceutical Botany, Faculty of Pharmacy, Mahidol University, Thailand; BPI: US National Fungus Collections, Maryland, USA; WM: Agricultural Research Division, Gezira Research Station, Wad Medani, Sudan; HMAS: Herbarium Mycologicum Academiae Sinicae, Beijing, China; K: Royal Botanic Gardens, Kew, England.

[a] private collection no.

[b] Sequence downloaded from GenBank.

evergreen conifer, mainly distributed in the forest regions of the Qilian Mountains (Liu et al. 2006). No *Gymnosporangium* species has previously been reported on *J. przewalskii*. Because morphological observations and phylogenetic analyses confirmed that the fungus is distinct from other *Gymnosporangium* species, we describe it here as new.

Materials & methods

Specimens

The fungus-infected branches were collected in Qinghai and Sichuan provinces in China, and their herbarium specimens were deposited in the Mycological Herbarium, Museum of Beijing Forestry University, Beijing, China (BJFC).

Morphological observation

Teliospores were scraped from the herbarium specimens and mounted in a drop of lactophenol-cotton blue solution. The slide preparations were observed under a Leica DM2500 microscope. The length, width, and wall thickness of 30–50 teliospores from each specimen were measured using a MicroView MVC TWAIN Image Analyzer.

Phylogenetic analysis

Whole genomic DNA from the teliospores was extracted following the methods described by Tian et al. (2004). DNA concentrations were estimated by electrophoresis in 1.2% agarose gels. The D1/D2 region of nuclear LSU rDNA was amplified with the primer pair No. 4 (5′-ACCCGCTGAAYTTAAGCATAT-3′) and No. 11 (5′-CTCCTTGGTCCGTGTTTCAAGACGC-3′) (Van der Auwera et al. 1994). The ITS and 5.8S region of rDNA were amplified with the primer pair ITS1 (5′-TCCGTAGGTGAACCTGCGG-3′) (White et al. 1990) and ITS4B (5′-CAGGAGACTTGTACA CGGTCCAG-3′) (Gardes & Bruns 1993). Amplifications were performed in 25 μl of PCR solution containing 1 μl of DNA template, 1 μl of sense primer (10 μM), 1 μl of antisense primer (10 μM), 12.5 μl of 2×Es Taq MasterMix (Cwbio, Beijing, China), and 9.5 μl of ddH_2O. The PCR conditions were as follows: 95°C for 3 min, 35 cycles of 95°C for 30 s, 55°C for 1 min, and 72°C for 1 min, and a final step of 72°C for 10 min. PCR products were purified and cloned for sequencing (Invitrogen, Beijing, China). A sequence of *Puccinia graminis* obtained from GenBank was used as outgroup (Yun et al. 2009).

The sequences newly obtained in this study and additional sequences obtained from GenBank are listed in Table 1. Sequences were aligned using ClustalX (Thompson et al. 1997). The sequence alignment has been deposited at TreeBase (http://www.treebase.org/) under the accession number 17721. Maximum parsimony (MP) analysis was carried out using the heuristic search option with 1,000 random-addition sequences and tree bisection and reconnection as the branch-swapping algorithm implemented in PAUP v.4.0b10 (Swofford 2002). In the MP analyses, gaps were treated as missing data, and all characters were equally weighted. Clade stability was assessed using a bootstrap analysis with 1,000 replicates (Felsenstein 1985). Other measures calculated were tree length (TL), consistency index (CI), retention index (RI), and rescaled consistency (RC). Bayesian analysis was performed with MrBayes 3.1.2 (Ronquist & Huelsenbeck

2003) using the Markov Chain Monte Carlo (MCMC) method; the GTR model was used with gamma-distributed rate variation, and the Markov chains were run for 1,000,000 generations. The trees were sampled every 100 generations, producing 10,000 total trees.

Table 2. Comparison of telium habit and teliospore morphology between *Gymnosporangium huanglongense* and its morphological allies.

Species	Telia		Teliospore	
	Position	Shape	Size (μm)	Germ pores
G. huanglongense	caulicolous	conic or irregular	53–100 × 14–25	2/cell, near septum (or 1 apical + 1 near septum in distal cell)
G. clavariiforme[a,b,c]	caulicolous	terete or slightly compressed	38–105 × 12–23	2/cell, near septum
G. fusisporum[b,d]	caulicolous	conic or laterally compressed	46–100 × 16–27	1(–2)/cell, near septum
G. gracile[b,e]	caulicolous	terete	45–90 × 14–20	2/cell, near septum

References: [a] Parmelee (1965); [b] Kern (1973); [c] Yun et al. (2009); [d] Zhuang (2012); [e] Fischer (1930).

Taxonomy

Gymnosporangium huanglongense Y.M. Liang & B. Cao, **sp. nov.** Plate 1

MycoBank MB 814684

Differs from *Gymnosporangium fusisporum* by the basal cell of its two-celled teliospores possessing two pores near the septum, and the distal cell possessing either two pores near the septum or occasionally an apical pore and one pore near the septum.

Type: China, Sichuan Prov., 32°45′06″N 103°48′12″E, alt. 3316 m, on *Juniperus przewalskii*, 24 Apr 2015, B. Cao & X.L. Fan (**Holotype**, BJFC-R01984; GenBank KT719167, KT719161).

Etymology: The specific epithet *huanglongense* refers to type locality of this species.

Spermogonia, aecia, and uredinia not found. Telia caulicolous, with little or no hypertrophy on the smaller branches, often conic or irregular, 1–3 mm high, brown to chestnut-brown; teliospores two-celled, rarely one-celled, fusiform, usually narrowed above and below, more or less constricted at the septum, yellowish brown, 53–100 × 14–25 μm; walls 0.7–1.7 μm thick; the basal cell with two pores near the septum, and the distal cell with two pores either both near the septum or occasionally (c. 3%) one apical and one near the septum; pedicels ≤200 μm long.

Other Specimens examined: On *Juniperus przewalskii*: **China**, **Sichuan Prov.**, 32°45′06″N 103°48′12″E, alt. 3307 m, 24 Apr 2015, B. Cao & X.L. Fan (BJFC-R01982; BJFC-R01985, GenBank KT719168, KT719162); **Qinghai Prov.**, 35°18′33″N 101°56′30″E, alt. 2934 m, 7 Apr 2015, F. Z. Han (BJFC-R01965; BJFC-R01966).

Comments: The telia of the new species are caulicolous and scattered, often conic or irregular, and *J. przewalskii* was not previously known as a

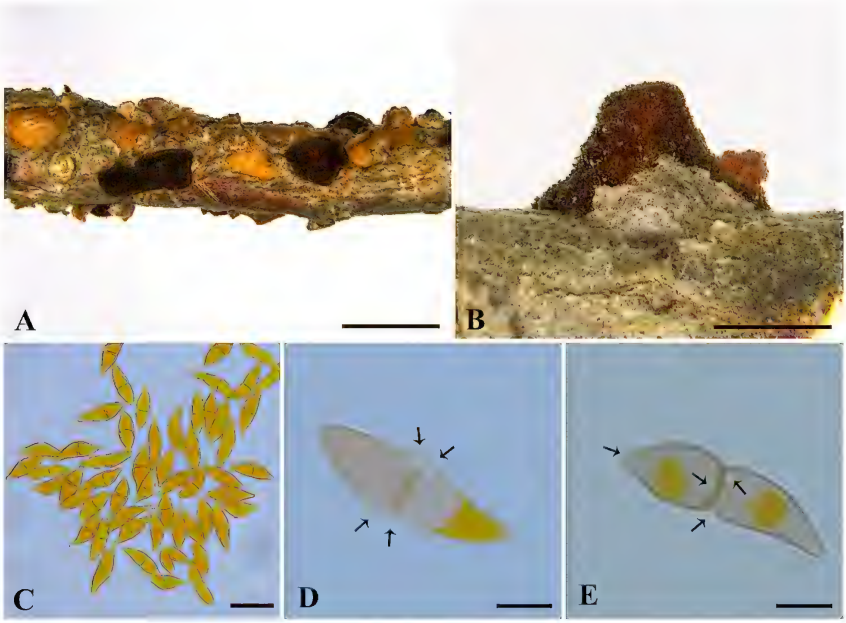

Plate 1. *Gymnosporangium huanglongense* (holotype, BJFC-R01984). A. telia formed on a branchlet; B. an enlarged view of a telium; C. teliospores. D. teliospore with two septal germ pores in each cell (arrows); E. teliospore with septal and apical germ pores (arrows). Scale bars: A, B = 3 mm; C = 70 μm; D, E = 20 μm.

Gymnosporangium host. The new species is morphologically similar to three *Gymnosporangium* species, *G. clavariiforme*, *G. fusisporum*, and *G. gracile*, but *G. huanglongense* can be distinguished from them by morphological characteristics (Table 2). *Gymnosporangium clavariiforme* and *G. gracile* differ by their terete telia (Fischer 1930, Parmelee 1965, Kern 1973, Yun et al. 2009), and *G. fusisporum* differs by its teliospore cells that have only one (rarely 2) pores near the septum (Kern 1973, Zhuang 2012). Additionally, the phylogenetic analyses supports *G. huanglongense* as distinct from these three species (Plates 2, 3).

The aligned ITS dataset from 16 ingroup taxa including nine terminal clades consisted of 713 characters, of which 311 were parsimony-informative, 322 were invariant, and 80 variable characters were parsimony-uninformative. The MP analysis of sequence data yielded a single parsimonious tree (TL = 757, CI = 0.745, RI = 0.800, and RC = 0.596). Bayesian analysis resulted in the same topology with an average standard deviation of split frequencies of 0.006386. In the LSU rDNA phylogenetic analyses, 28 ingroup taxa clustered into thirteen

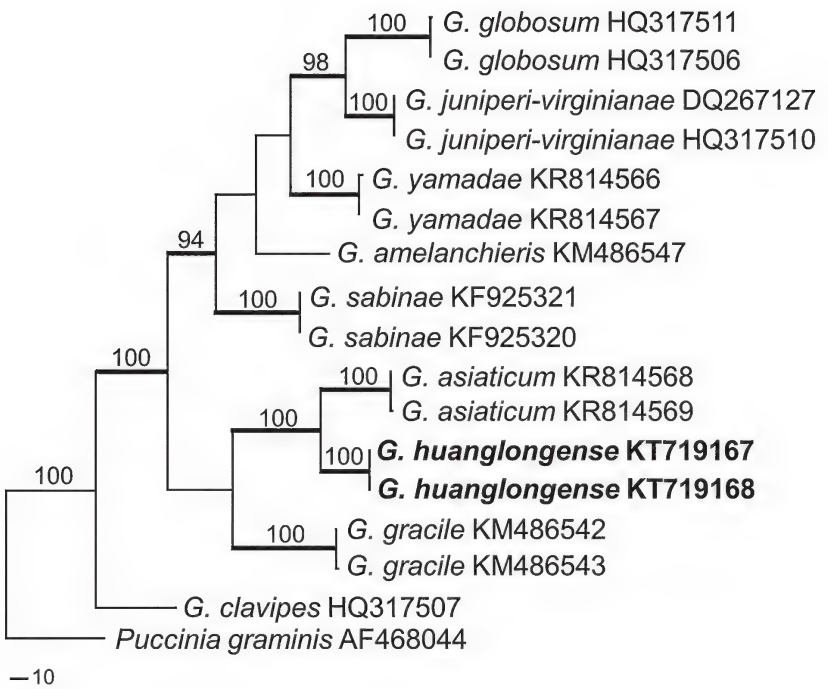

Plate 2. ITS phylogenetic tree of *Gymnosporangium* spp., constructed by maximum parsimony and Bayesian methods. Node support is presented as: parsimony bootstrap values >90%. Thickened branches indicate PP > 0.90 from the Bayesian inferences. The new species is shown in bold.

terminal clades. The final aligned dataset consisted of 593 characters of which 501 were invariant. MP analyses of the remaining 54 parsimony-informative characters resulted in 20 trees. We selected the tree with the shortest length (TL = 140, CI = 0.743, RI = 0.865, and RC = 0.642) as the current tree. Bayesian analysis resulted in an average standard deviation of split frequencies of 0.010532. The topology of the ITS phylogram was consistent with the tree estimated using the LSU rDNA region (Plates 2, 3), indicating that the *G. huanglongense* sequences were distinct from those of other species which are available in GenBank database.

In the LSU rDNA phylogenetic analyses, specimens of *G. huanglongense* formed a distinct lineage with high support values (97 MPBS; 0.99 BPP). The other four species, *G. asiaticum*, *G. unicorne*, *G. confusum*, and *G. fusisporum*

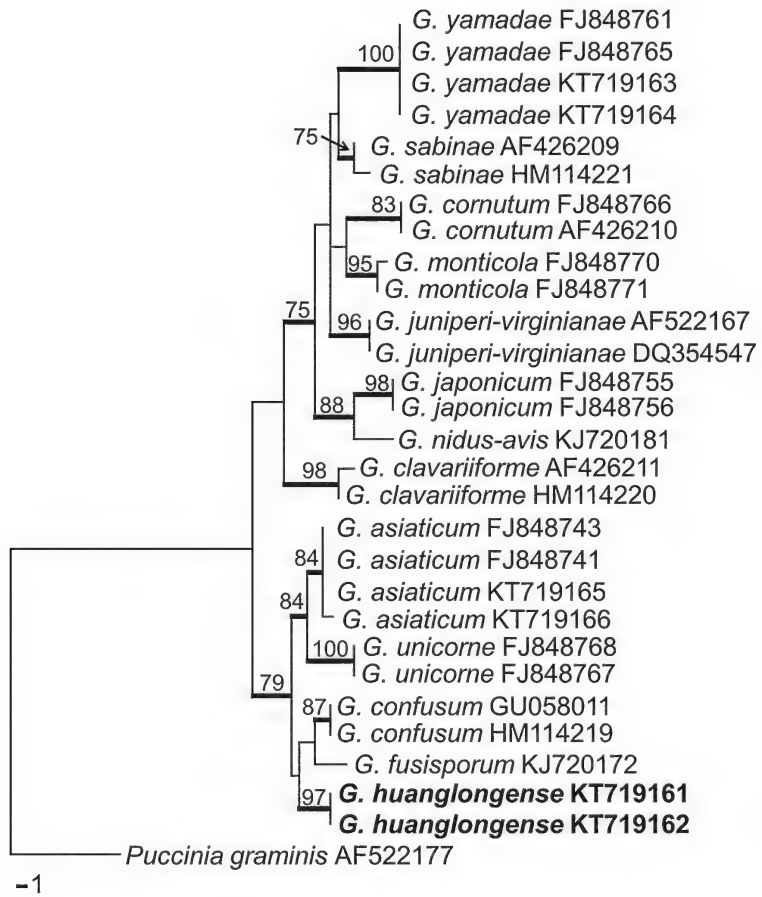

Plate 3. LSU phylogenetic tree of *Gymnosporangium* spp., constructed by maximum parsimony and Bayesian methods. Node support is presented as: parsimony bootstrap values >75%. Thickened branches indicate PP > 0.75 from the Bayesian inferences. The new species is shown in bold.

were closely related to *G. huanglongense* based on LSU rDNA analyses (79 MPBS; 0.87 BPP). However, these four species differ morphologically from *G. huanglongense*. As previously discussed, *G. fusisporum* differs by its smaller number of teliospore germ pores; and the other three species differ by their shorter teliospores: *G. asiaticum* 35–45 µm; *G. confusum* 35–48 µm; and *G. unicorne* 31–47 µm (Kern 1973, Yun et al 2009).

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New species of *Dictyochaeta* and *Wardomyces* from soil

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Abstract — Three new species, *Dictyochaeta brachysetula*, *D. chinensis*, and *Wardomyces microsporus* from soil in China, are described and illustrated. The type specimens (dried cultures) and living cultures are deposited in the Herbarium of Shandong Agricultural University, Plant Pathology (HSAUP), and the Herbarium of Institute of Microbiology, Academia Sinica (HMAS).

Key words — asexual fungi, dematiaceous hyphomycetes, taxonomy

Introduction

The genus *Dictyochaeta* was established by Spegazzini (1923) and is characterized by macronematous, mononematous, septate, pale brown to dark brown conidiophores that produce mono- or polyphialidic, sympodially proliferating conidiogenous cells that often have conspicuous and flared collarettes. Frequently, sterile or fertile setae are associated with the conidiophores and together these can form small clusters originating from a knot of superficial hyphae. The conidia are hyaline, smooth, and typically falcate (but can be ellipsoid, clavate, fusoid, or cylindrical), 0–1(–3)-septate, and with or without setulae (Whitton et al. 2000).

Wardomyces, established by Brooks & Hansford (1923), is characterized by semi-macronematous, mononematous, straight or flexuous, hyaline or subhyaline, smooth, branched conidiophores that produce polyblastic, penicillately arranged, determinate, ampulliform, subspherical, clavate, doliform or ellipsoidal conidiogenous cells. Conidia are solitary, acropleurogenous, ellipsoidal, ovoid, oblong rounded at the apex or navicular, often truncate at

the base, brown or blackish brown, smooth, each with a longitudinal germ slit, 0–1-septate. MycoBank lists eight species of this genus.

During a survey on soil dematiaceous hyphomycetes in China, two *Dictyochaeta* and one *Wardomyces* species were obtained that did not match with other congeneric species and are therefore described as new taxa. They

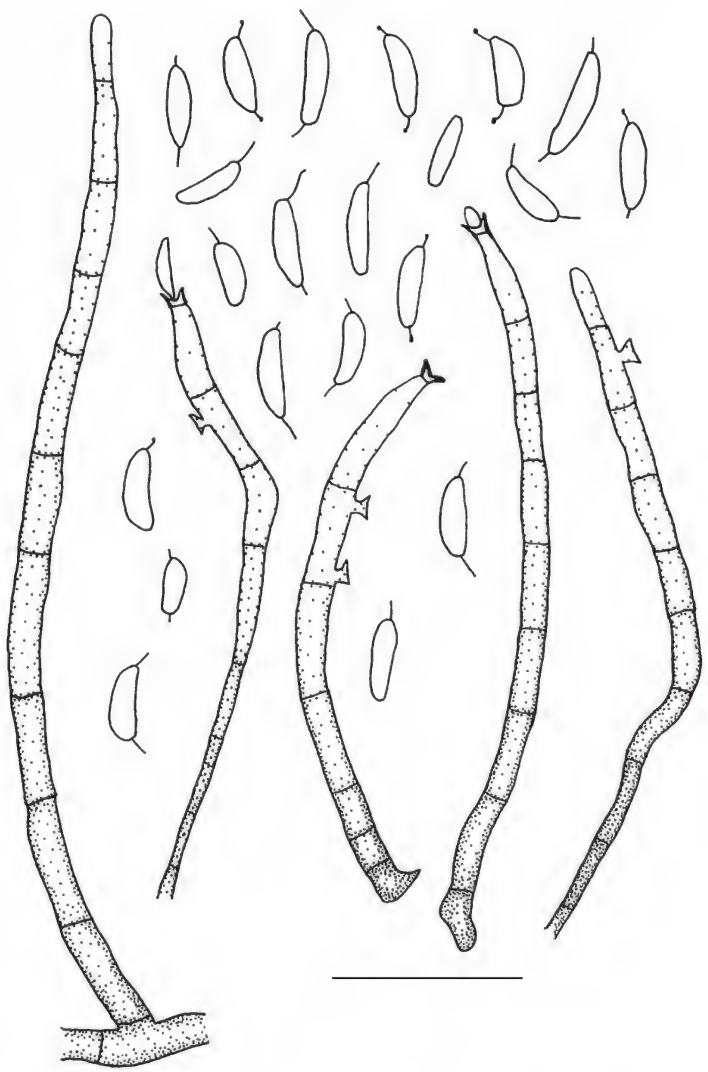

FIG. 1. *Dictyochaeta brachysetula* (ex holotype HSAUP II_{06}9038). Conidia, setae, conidiophores, and collarettes. Scale bar = 25 μm.

were isolated onto potato dextrose agar (PDA) and are described from this medium. Specimens and living cultures are conserved in the Herbarium, Department of Plant Pathology, Shandong Agricultural University, Taian, China (HSAUP), and the Herbarium Mycologium, Institute of Microbiology, Academia Sinica, Beijing, China (HMAS).

Dictyochaeta brachysetula Y.L. Jiang & T.Y. Zhang, **sp. nov.** Fig. 1

MycoBank MB 815281

Differs from *Dictyochaeta fertilis* and *D. pakhalensis* by its wider conidia and shorter setulae.

Type: China, Sichuan Province, Luding County, from a vegetable plot soil, 24 June 2006, Y.L. Jiang (**Holotype**, HSAUP II_{06}9038 [dried culture]; **isotype**, HMAS 196298).

Etymology: in reference to the short setulae.

Colonies on PDA effuse, greyish brown, hairy, reaching 3–4 cm in diameter in 2 weeks at 25 °C. Mycelium superficial and immersed; hyphae hyaline to pale brown, branched, septate, smooth, 1–3.5 µm wide. Setae straight or curved, pale brown to brown, paler and almost always fertile towards the apex where there are persistent collarettes, smooth, ≤380 µm long, 2.5–4.5 µm thick. Conidiophores solitary or in small groups often associated with setae, rather closely septate, pale brown to brown, smooth, ≤150 µm long, 2.5–4 µm thick, polyphialidic; collarettes funnel-shaped with thick walls. Conidia fusiform, curved, hyaline, smooth, aseptate, 7–15 × 2.5–4 µm, with a setula not more than 5 µm long at each end or sometimes only at the apical end.

Comments: In having fertile setae and in morphology of conidia and collarettes, *Dictyochaeta brachysetula* closely resembles *D. fertilis* (S. Hughes & W.B. Kendr.) Hol.-Jech. and *D. pakhalensis* (S.M. Reddy & S.S. Reddy) Whitton et al.. However, *D. fertilis* has narrower conidia (10–15 × 2–3 µm) and longer setulae (5–10 µm; Holubová-Jechová 1984); and *D. pakhalensis* has smaller conidia (6–11 × 1.75–2 µm) but longer setulae (4–8 µm; Reddy & Reddy 1978, as *Codinaea pakhalensis*).

Dictyochaeta chinensis Y.L. Jiang & T.Y. Zhang, **sp. nov.** Fig. 2

MycoBank MB 815282

Differs from *Dictyochaeta assamica* by its bigger conidia and shorter setulae.

Type: China, Guizhou Province, Leishan County, from a mountain soil, 18 Sept. 2005, Y.L. Jiang (**Holotype**, HSAUP II_{05}1019 [dried culture]; **isotype**, HMAS 196299).

Etymology: in reference to the country where the fungus was isolated.

Colonies on PDA effuse, greyish black, hairy. Mycelium superficial and immersed; hyphae pale brown, branched, septate, smooth, 1–2.5 µm wide. Setae

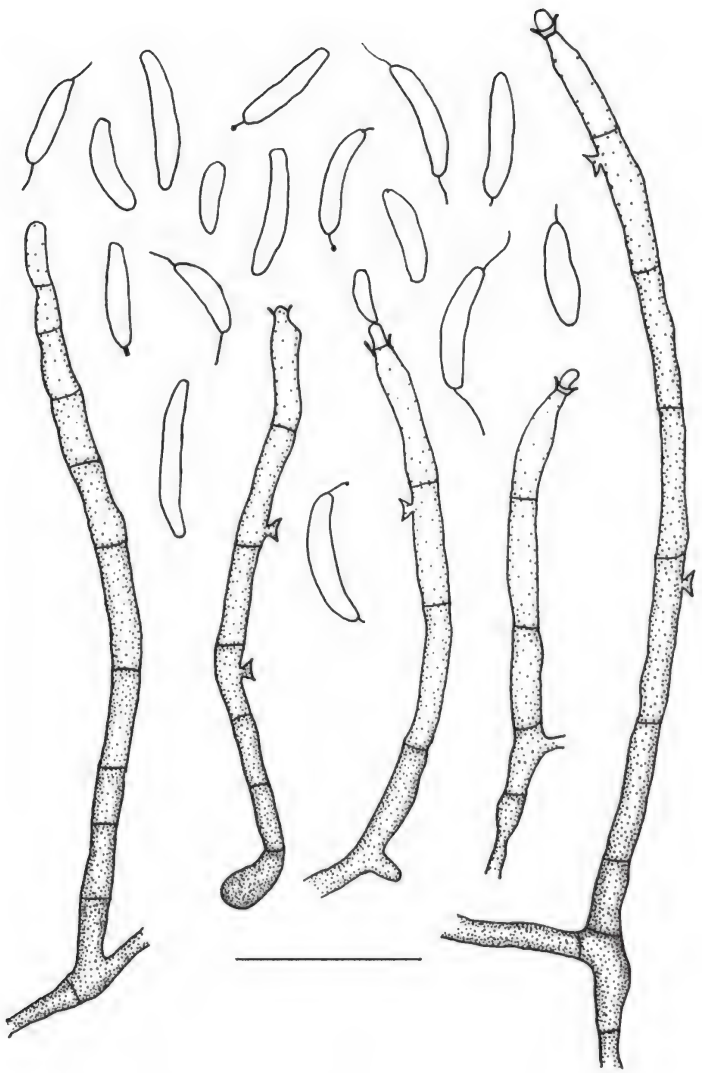

FIG. 2. *Dictyochaeta chinensis* (ex holotype HSAUP II_{05}1019). Conidia, setae, conidiophores, and collarettes. Scale bar = 25 μm.

straight or curved, septate, pale brown to brown, paler and almost always fertile towards the apex where there are persistent collarettes, smooth, ≤320 μm long, 2.5–5 μm thick. CONIDIOPHORES solitary or in small groups often associated with setae, straight or flexuous, septate, pale brown to brown, smooth, 50–200

× 2.5–4 μm, polyphialidic; collarettes funnel-shaped with thick walls. Conidia fusiform or sometimes cylindrical, mostly curved, hyaline, smooth, aseptate, 10–20 × 2–4 μm (commonly 14 × 3 μm), with setulae 1.5–8 μm long, usually on both ends of the conidium but sometimes absent or only on one end.

Comments: Morphologically, *Dictyochaeta chinensis* resembles *D. assamica* (Agnihothr.) Aramb. et al.. However, *D. assamica* has smaller conidia (14–16 × 2.5–3 μm) with longer setulae (9–14 μm) always on both ends (Arambarri et al. 1988).

Wardomyces microsporus Y.L. Jiang & T.Y. Zhang, **sp. nov.** Fig. 3

MycoBank MB 815283

Differs from other species of *Wardomyces* by its smaller ellipsoidal, subspherical, or broadly ovate conidia.

Type: China, Hubei Province, Huanggang City, from a vegetable plot soil, 12 Oct. 2004, Y.L. Jiang (**Holotype**, HSAUP II_{04}6201 [dried culture]; **isotype**, HMAS 1962100).

Etymology: in reference to the small conidia.

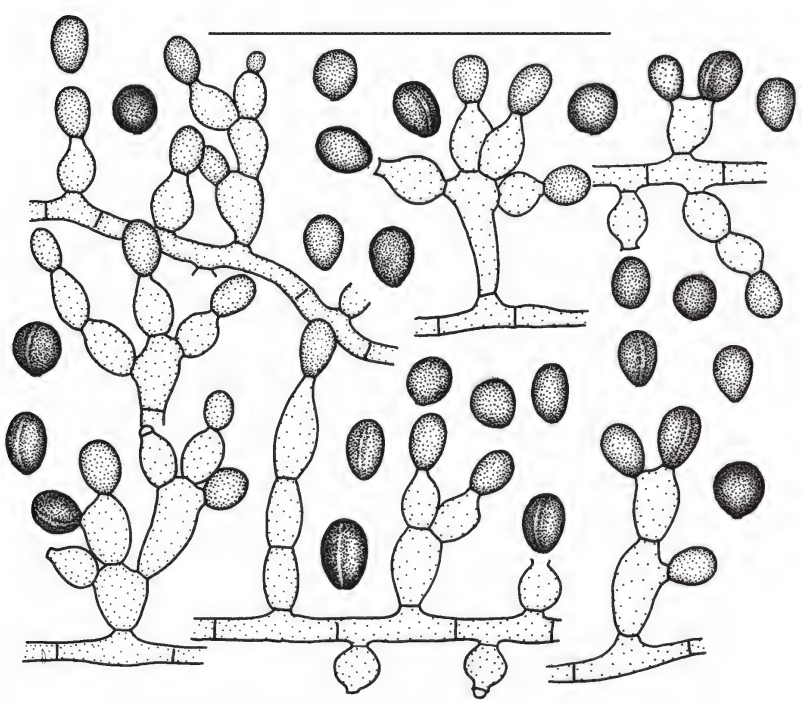

Fig. 3. *Wardomyces microsporus* (ex holotype HSAUP II_{04}6201). Conidia, conidiophores, and conidiogenous cells. Scale bar = 25 μm.

Colonies effuse, black, growing rather slowly on PDA, reaching 0.9 cm in diameter in 2 weeks at 25 °C. Mycelium superficial and immersed; hyphae pale brown, branched, septate, smooth, 1–2.5 µm wide. Conidiophores arising laterally on hyphae, irregularly branched, pale brown, short. Conidiogenous cells terminal, polyblastic, discrete, inflated, broadly obpyriform or subspherical, smooth, pale brown, 2.5–4 × 2–2.5 µm. Conidia arise successively, ellipsoidal, subspherical or broadly ovate, obtuse at the apex and slightly truncated at the base, aseptate, smooth, thick-walled, nut-brown to dark brown, 2.5–4.5 × 2.5–3 µm, with a single longitudinal pale-colored germ slit through which a lateral germ tube develops on germination.

Comments: The other seven accepted *Wardomyces* species—*W. anomalus* F.T. Brooks & Hansf., *W. columbinus* (Demelius) Hennebert, *W. humicola* Hennebert & G.L. Barron, *W. inflatus* (Marchal) Hennebert, *W. moseri* W. Gams, W. *ovalis* W. Gams, and *W. pulvinatus* (Marchal) C.H. Dickinson—have larger conidia, mostly navicular, ellipsoidal, or oblong (Ellis 1971; Gams, 1968, 1995; Hennebert 1968).

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Xylohyphopsis aquatica sp. nov., a new aquatic hyphomycete from China

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Abstract—A new aquatic hyphomycete, *Xylohyphopsis aquatica*, is described and illustrated from specimens collected on submerged wood in Jiangxi Province, China. *Xylohyphopsis aquatica* is morphologically characterized by its 0–1-septate, thin-walled, smooth, pale brown conidia in simple or branched chains, usually with a germ tube or short germination hypha at the distal end. A key to *Xylohyphopsis* species is provided.

Key words—freshwater fungi, lignicolous fungi, *Pezizomycotina*, taxonomy

Introduction

Freshwater habitats accommodate various fungal species. Numerous unique fungal taxa have been recently reported from such habitats, including a new phylum (Jones et al. 2011), some new orders (Pang et al. 2002, Raja et al. 2015), and numerous new genera and species (Hu et al. 2007, 2010, 2012a; Monteiro et al. 2014). During our investigation on lignicolous fungi from freshwater habitats in China (Hu et al. 2012b, 2013), several novel taxa have been discovered. Among them is a hyphomycetous fungus with morphological characters of *Xylohyphopsis* W.A. Baker & Partr. (Partridge et al. 2000) but differing from other described *Xylohyphopsis* species in its unique morphological characters and habitat. It is proposed here as new.

Materials & methods

Unidentified wood samples submerged in freshwater were collected in China and incubated in moist chambers at room temperature (c. 25 °C). Samples were examined

for fungal fruiting bodies using a dissecting microscope. Observations and photographs were prepared from materials mounted in water and examined with a Nikon Ni compound microscope. Voucher specimens are deposited in the Herbarium of Fungi, Jiangxi Agricultural University, Nanchang, China (HFJAU).

Taxonomy

Xylohyphopsis aquatica J.E. Huang, H.Y. Song, Jian Ma & D.M. Hu, **sp. nov.** Fig. 1

MycoBank MB 815392

Differs from *Xylohyphopsis curta* by its smaller unicellular conidia and from *X. lignicola* by its readily broken conidial chains and its much smaller, thin-walled, smooth, pale brown conidia.

Type: China, Jiangxi Province, Nanchang, Meiling Mountain, in a stream on submerged wood, 13 Oct. 2015, J.-E. Huang (**Holotype**, HFJAU 0011).

Etymology: *aquatica*, referring to the aquatic habitat of the fungus.

Colonies on wood substrate effuse, spreading widely, powdery with abundant conidial formation, dark brown. Mycelium mostly immersed, composed of branched, septate, smooth, pale brown hyphae, 1–2 μm in diam. Conidiophores reduced to conidiogenous cells, micronematous, essentially unmodified emergent hyphae that merge gradually and subtly into conidial chains, single or in loose caespitose clusters, subhyaline or pale to medium brown, erect, straight, cylindrical. Conidial chains often arising as lateral outgrowths of repent hyphae in close proximity to one another and frequently from adjacent hyphal cells, 20–90 μm long, and usually with a germ tube or short germination hypha at the distal end. Conidia dry, in simple or branched acropetal chains, acropleurogenous, pale brown, ellipsoidal to broadly fusiform, 0–1-septate, slightly truncate or acute at both ends, thin-walled, smooth, 1-celled conidia 2–5 × 1–3 μm, 2-celled conidia 3–7.5 × 1–3 μm. Conidia secession schizolytic.

Additional specimens examined: **China**, **Jiangxi Province**, Nanchang, Meiling Mountain, in a stream on submerged wood, 13 Oct. 2015, J.-E. Huang (HFJAU 0012).

Discussion

Partridge et al. (2000) established *Xylohyphopsis* for two species recombined from *Xylohypha* (Fr.) E.W. Mason: *Xylohyphopsis curta* (Corda) W.A. Baker & Partr. as the type species and *X. lignicola* (B. Sutton) W.A. Baker & Partr. Partridge et al. (2000) noted the following differences between *Xylohyphopsis* and *Xylohypha*: 1) the conidial chains of *Xylohypha* are consistently moniliform, while in *Xylohyphopsis* the conidia are separated by broad transverse septa; 2) in *Xylohypha*, the conidia are consistently unicellular, while there are some multicellular conidia in *Xylohyphopsis*; 3) conidia disarticulate in a yeast-like manner in *Xylohypha*, while the conidia cleave schizolytically at the distinct wide septa.

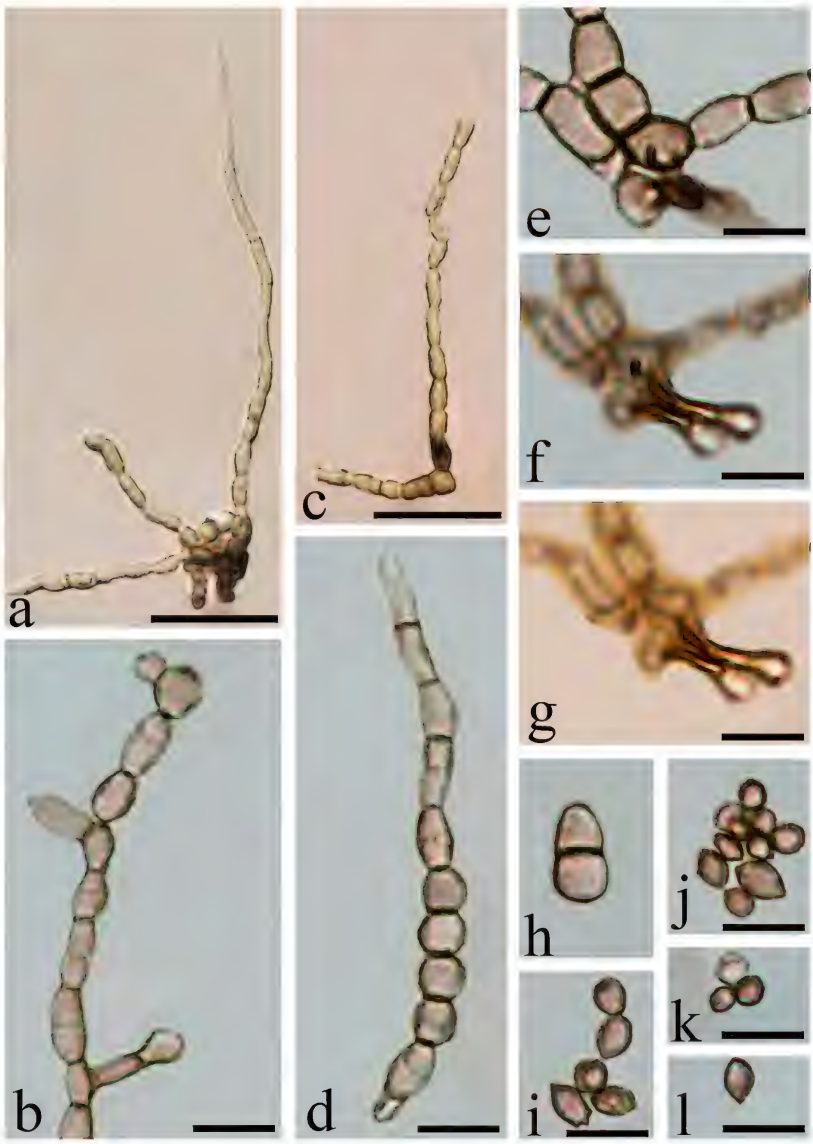

Fig. 1. *Xylohyphopsis aquatica* (holotype, HFJAU 0011). a. Conidiophore with conidial chains. b–d. Conidial chains. e–g. Conidiogenous cells. h–l. Conidia. Scale bars: a, c = 20 μm; b, d–l = 5 μm.

Xylohyphopsis curta differs from *X. aquatica* by its production of conidia with 0–4 (or more) septa and by its much larger unicellular conidia (6.5–8 × 5–6.5 μm; Partridge et al. 2000); and *X. lignicola* differs by its conidial chains

that do not readily break up and by its much larger, dark brown, thick walled, verrucose conidia (5–6.5 µm diam.; Sutton 1973, as *Xylohypha lignicola*).

Key to the species of *Xylohyphopsis*

1. Conidia dark brown, thick-walled, verrucose..... *X. lignicola*
1. Conidia pale to mid brown, smooth.....2
2. Conidia 0–1-septate, unicellular conidia 2–5 × 1–3 µm .....*X. aquatica*
2. Conidia 0–4-septate, unicellular conidia 6.5–8 × 5–6.5 µm .....*X. curta*

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Annulohypoxylon (*Xylariales*) from western Paraná, Brazil

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Abstract — *Annulohypoxylon parvodiscum* sp. nov. is proposed, based on small ostiolar disc of *bovei*-type, olivaceous grey pigment, and ellipsoid ascospores (9–13 × 3–5 µm); and three other species of *Annulohypoxylon* are reported from western Paraná State, Brazil: *A. macrodiscum*, *A. nitens*, and *A. stygium*. A key for identification of studied taxa is provided.

Key words — *Ascomycota*, *Hypoxyloideae*, mycobiota, taxonomy, *Xylariaceae*

Introduction

Annulohypoxylon Y.M. Ju et al. was segregated from *Hypoxylon* Bull., based on morphological, chemotaxonomic and molecular data (Hsieh et al. 2005, Fournier et al. 2010). It covers taxa previously placed in *Hypoxylon* sect. *Annulata* J.H. Miller diagnosed by the presence of carbonaceous stromatic layer surrounding perithecia, projecting ostioles above the stromatic surface, with a conspicuous to inconspicuous annulate disc, and ascospores with dehiscent perispores (Ju & Rogers 1996). The genus comprises c. 40 species, of which sixteen are known from Brazil (Pereira 2015), most of them reported from the states of Bahia (Northeast) and Rio Grande do Sul (South). From Paraná State, only *A. stygium* has been reported (Meijer 2010).

In order to improve the knowledge on the diversity and geographical distribution of the *Xylariaceae* from western Paraná State, Brazil, a survey was undertaken (Cruz & Cortez 2015a, 2015b); here we present the results for the genus *Annulohypoxylon*.

Materials & methods

Specimens were collected from 2013 to 2014 in São Camilo State Park (abbreviated as PESC), municipality of Palotina, western Paraná State, Brazil (24°18′00″–19′30″S 53°53′30″–55′30″W) which comprises a relict of seasonal semi-deciduous forest (Atlantic Forest Domain; Kozera & Peluci 2015).

Morphology was examined according to Ju & Rogers (1996) and colors were based on Rayner (1970). Microscopic features were examined in 10% KOH, and measured in distilled water preparations; asci were mounted in Cotton Blue, except for the apical ring, examined in Melzer's reagent. Ascospores were analyzed under scanning electron microscope (SEM) Jeol JSM-6360LV, at the Center of Electron Microscopy of the Universidade Federal do Paraná, following Suwannasai et al. (2012). All specimens are preserved in the Herbarium, Department of Biodiversity, Universidade Federal Paraná, Palotina, Brazil (HCP), except for the *A. parvodiscum* holotype in the Herbarium, Department of Botany, Universidade Federal Paraná, Curitiba, Brazil (UPCB).

Taxonomy

Annulohypoxylon macrodiscum Jad. Pereira, J.D. Rogers & J.L. Bezerra, Mycologia 102: 250. 2010. PLATES 1A–D, 3A

STROMATA pulvinate to effused-pulvinate, 3–25 mm long × 5–14 mm broad × 0.5–1.5 mm thick; surface fuscous black (104) with brown vinaceous tone; blackish granules beneath surface and among perithecia, with KOH-diluted pigments, greenish olivaceous (90) or dull green (70); tissue below the perithecial layer, 0.3–0.5 mm thick. PERITHECIA spherical to obovoid, 0.6–1 × 0.5–1 mm, with perithecial mounds ¼ to ½ exposed. OSTIOLES conical-papillate, surrounded by a *truncatum*-type disc, 0.4–0.8 mm diam. ASCI cylindrical, 114–121 × 5–7 µm; spore-bearing part 65–80 µm, stipe 40–50 µm; apical ring amyloid, inconspicuous, discoid, 0.5 × 1–1.3 µm. ASCOSPORES brown to dark brown, ellipsoid-inequilateral, with narrowly rounded ends, 7–12 × 3.5–5 µm, with straight germ slit spore-length on the convex side; perispore dehiscent in KOH; epispore smooth; surface smooth under SEM.

SPECIMENS EXAMINED: **BRAZIL. PARANÁ STATE**: Palotina, PESC, 13 Jun 2013, leg. K.S. Cruz 104 (HCP 583), 105 (HCP 584); 13 Dec 2013, leg. K.S. Cruz 179 (HCP 585), 180 (HCP 586).

HABITAT AND DISTRIBUTION: On rotting wood, in the board of forest trail. Known from Atlantic Forest, states of Bahia (Pereira et al. 2010) and Paraná.

NOTES: *Annulohypoxylon macrodiscum* is diagnosed by the wide ostiolar disc and spherical to obovoid perithecia (Pereira et al. 2010). It is morphologically similar to *A. truncatum* (Schwein.) Y.M. Ju et al., but as discussed by Pereira et al. (2010), *A. truncatum* has smaller ostiolar disc (0.2–0.4 mm diam.) and perithecia (0.4–0.8 mm), which is also spherical (Ju & Rogers 1996). Ascospores of Paraná collections presented a slight variation in size, in comparison to type

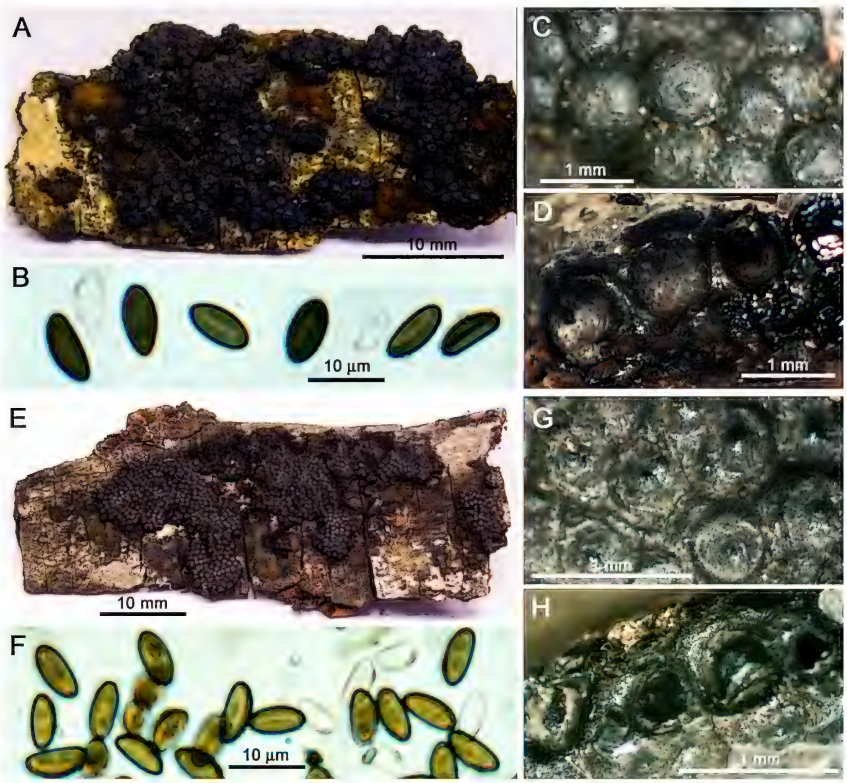

Plate 1. ***Annulohypoxylon macrodiscum***. A: stroma; B: ascospores; C: top view of disc; D: perithecia, sectioned. ***Annulohypoxylon nitens***. E: stroma; F: ascospores; G: top view of disc; H: perithecia, sectioned.

(8–11 × 4–5 µm; Pereira et al. 2010), but this is assumed to be intraspecific variation. The species was described from Northeastern Brazil (Pereira et al. 2010) and is now reported from Southern Brazil, but probably it is widespread throughout the Atlantic Forest biome.

Annulohypoxylon nitens (Ces.) Y.M. Ju, J.D. Rogers & H.M. Hsieh, Mycologia 97: 861. 2005. Plates 1E–H, 3B

Stromata glomerate to effused-pulvinate, 18–35 mm long × 5–12 mm broad × 0.5–1 mm thick, with perithecial mounds ¼ to ½ exposed; surface dark brown vinaceous (84) to fuscous black (104), with a white tissue covering the ostiolar disc; blackish granules beneath surface and among perithecia, with KOH-diluted pigments greenish olivaceous (90) or dull green (70); black tissue

below the perithecia inconspicuous, 0.2 mm thick. Perithecia spherical, 0.6–1 mm diam. Ostioles conical-papillate, encircled with a flattened *bovei*-type disc 0.3–0.5 mm diam. Asci 80–140 × 4–6 µm, spore-bearing parts 60–80 µm, stipe 21.5–59 µm, with apical ring amyloid, discoid, 0.5 × 1–1.5 µm. Ascospores light brown to brown, ellipsoid-inequilateral, with narrowly rounded ends, 6.5–9 × 3–5 µm, with straight germ slit spore-length on the convex side; perispore dehiscent in KOH, smooth; epispore smooth; surface smooth under SEM.

Specimens examined: **BRAZIL. Paraná State**: Palotina, PESC, 13 Jun 2013, leg. K.S. Cruz 100 (HCP 587); 10 Sep 2013, leg. K.S. Cruz 139 (HCP 588); 7 Oct 2013, leg. K.S. Cruz 173 (HCP 589); 18 Oct 213, leg. K.S. Cruz 184 (HCP 590), 186 (HCP 591); 5 Nov 2013, leg. K.S. Cruz 169 (HCP 592); 20 Jan 2014, leg. K.S. Cruz 196 (HCP 593), 198 (HCP 594); 25 Mar 2014, leg. K.S. Cruz 218 (HCP 595).

Habitat and distribution: On rotting wood, in the forest board. Known from the Americas and Asia (Ju & Rogers 1996, Pereira et al. 2015).

Notes: According to Ju & Rogers (1996), *A. nitens* presents spherical perithecia. However, our specimens showed spherical to obovoid perithecia, and were determined in the sense of Hladki & Romero (2009), who reported similar materials from Argentina. Similar species are *A. truncatum* and *A. moriforme* (Henn.) Y.M. Ju et al., which differ in the presence of an ostiolar disc of *truncatum*-type (Ju & Rogers 1996). Known from the state of Bahia, *A. nitens* is a new record from Paraná State, where it was one of the most common xylariaceous fungi sampled in PESC.

Annulohypoxylon parvodiscum K.S. Cruz & Cortez, **sp. nov.**

MycoBank MB 812745 Plates 2A–F, 3C

Differs from *Annulohypoxylon squamulosum* by its smooth vinaceous brown stromatal surface and larger ascospores.

Type: Brazil. Paraná State: Palotina, PESC, 13 June 2013, leg. K.S. Cruz 094 (**Holotype**, UPCB 81662; **isotype**, HCP 596).

Etymology: referring to the small (L., *parvus*) size of ostiolar disc (L., *discus*).

Stromata effused-pulvinate, 5–30 mm long × 3–8 mm broad × 0.5–0.8 mm thick; with inconspicuous perithecial mounds; surface brown vinaceous (84), smooth; blackish granules beneath surface and between perithecia, with KOH-diluted pigment olivaceous grey (121); tissue below the perithecial layer inconspicuous. Perithecia spherical to slightly obovoid, 0.3–0.5 × 0.2–0.4 mm diam. Ostioles slightly papillate, surrounded by a *bovei*-type disc, 0.1–0.2 mm diam. Asci cylindrical, 69–157.5 × 5–10 µm; spore-bearing part 68–103 µm, stipe 17.5–76 µm; apical ring amyloid, inconspicuous. Ascospores brown to dark brown, ellipsoid-inequilateral, with narrowly rounded ends, 9–13 × 3–5

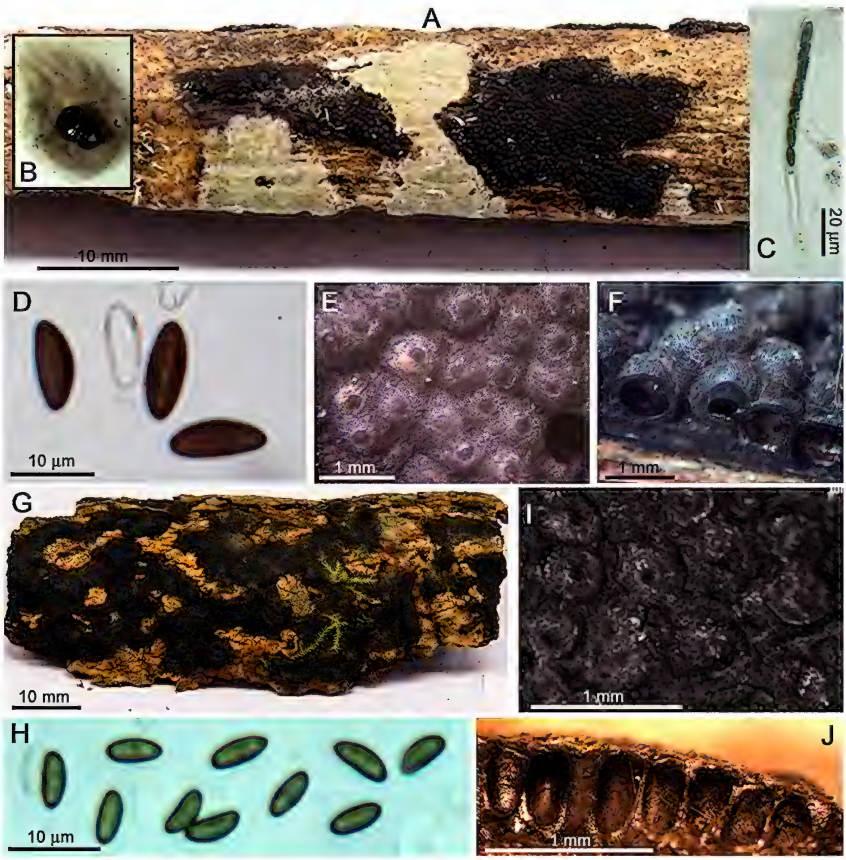

Plate 2. ***Annulohypoxylon parvodiscum*** (holotype). A: stroma; B: KOH-extractable pigment; C: asci; D: ascospores; E: top view of disc; F: perithecia, sectioned. ***Annulohypoxylon stygium***. G: stroma; H: ascospores; I: top view of disc; J: perithecia, sectioned.

µm, with straight germ slit spore-length, sometimes slightly sigmoid on the convex side; perispore dehiscent in KOH; epispore smooth; surface smooth under SEM.

Additional specimens examined: **BRAZIL. Paraná State**: Palotina, PESC, 10 Sept. 2013, leg. K.S. Cruz 144 (HCP 597); 18 Oct. 213, leg. K.S. Cruz 185 (HCP 598).

Habitat and distribution: Growing on decayed angiosperm trunk, in the board of forest trail. Known only from type locality.

Notes: *Annulohypoxylon parvodiscum* is similar to *A. archeri* (Berk.) Y.M. Ju et al., *A. microcarpum* (Penz. & Sacc.) Y.M. Ju et al., and *A. squamulosum* (Y.M.

Ju et al.) Y.M. Ju et al. all species bearing reduced ostiolar disc (0.1–0.2 mm). However, in *A. archeri* and *A. microcarpum*, the disc is of *truncatum*-type (Ju & Rogers 1996). *Annulohypoxylon squamulosum,* which also has a *bovei*-type disc, differs by its rough stromatal surface and smaller ascospores (6.5–8.5 × 3–4 µm; Ju et al. 2004).

Annulohypoxylon stygium (Lév.) Y.M. Ju, J.D. Rogers & H.M. Hsieh, Mycologia 97: 861. 2005. PLATES 2G–J, 3D

STROMATA hemispherical to effused-pulvinate, 9–10 mm long × 5–7 mm broad × 0.3–0.4 mm thick, with inconspicuous perithecial mounds; surface fuscous black (104), with some reddish brown tone; reddish brown granules beneath surface and among perithecia, KOH-diluted pigments greenish olivaceous (90) or dull green (70); tissue below the perithecial layer inconspicuous. PERITHECIA obovoid, 0.3–0.4 × 0.15–0.25 mm diam. OSTIOLES conical-papillate, surrounded by a *truncatum*-type disc 0.1–0.2 mm diam. ASCI cylindrical, 72–80 × 4–5 µm, spore-bearing part 56–62 µm, stipe 12–19 µm, apical ring amyloid, discoid, 0.5 × 1 µm. ASCOSPORES light brown, ellipsoid-inequilateral, with narrowly rounded ends, 5–7 × 2.5–3 µm, with straight germ slit spore-length on flattened side; perispore dehiscent in KOH; epispore smooth; surface smooth under SEM.

SPECIMENS EXAMINED: **BRAZIL. PARANÁ STATE**: Palotina, PESC, 16 May 2013, leg. K.S. Cruz 016 (HCP 578), 017 (HCP 579); 7 Oct 2013, leg. K.S. Cruz 174 (HCP 580), 183 (HCP 581); 5 Nov 2013, leg. K.S. Cruz 158 (HCP 582).

HABITAT AND DISTRIBUTION: On rotting wood, in the board of forest. Known from the Americas and Asia (Ju & Rogers 1996).

NOTES: The small ascospores and ostiolar disc and green stromatic pigment are diagnostic features for *A. stygium* (Ju & Rogers 1996). It looks like the African *A. atroroseum* (J.D. Rogers) Y.M. Ju et al., which differs by its pinkish stromatic surface (Ju & Rogers 1996). In Brazil, *A. stygium* has been reported from Amazon and Atlantic Forest biomes, including Paraná State (Meijer 2006, 2010; Pereira 2015).

Key for the *Annulohypoxylon* species from PESC, Paraná, Brazil

1. Ostiolar disc *bovei*-type 2
1. Ostiolar disc *truncatum*-type 3
2. KOH-extractable pigments olivaceous grey, ostiolar disc 0.1–0.2 mm ..... ***A. parvodiscum***
2. KOH-extractable pigments olivaceous green, ostiolar disc 0.3–0.5 mm ... ***A. nitens***
3. Ostiolar disc 0.1–0.2 mm, ascospores 5–7 × 2.5–3 µm ..... ***A. stygium***
3. Ostiolar disc 0.4–0.8 mm, ascospores 7–12 × 3.5–5 µm ..... ***A. macrodiscum***

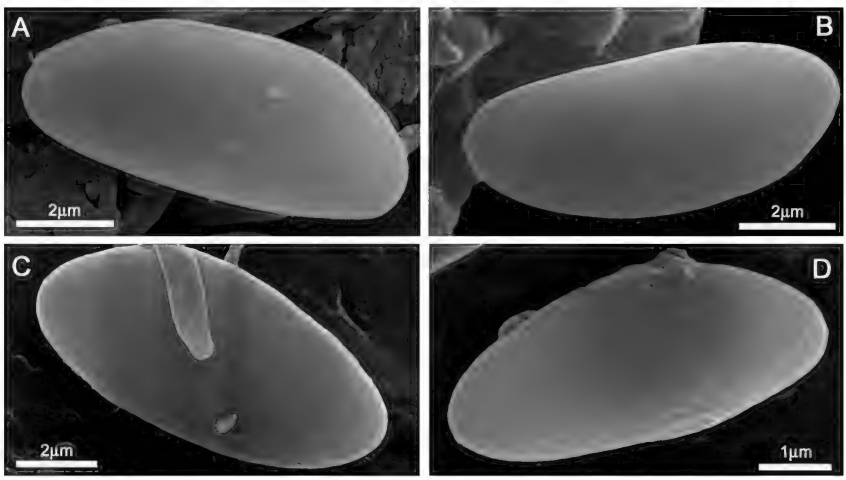

Plate 3. *Annulohypoxylon* ascospores (SEM).
A: *A. macrodiscum*. B: *A. nitens*. C: *A. parvodiscum*. D: *A. stygium*.

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First record of *Pileolaria terebinthi* (*Pucciniales*) in Pakistan

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Abstract—The rust fungus *Pileolaria terebinthi* is recorded for the first time in Pakistan, on *Pistacia chinensis*.

Key words—*Anacardiaceae*, Hazara Division, *Pileolariaceae*, taxonomy, *Uredinales*

Introduction

Rust-infected *Pistacia chinensis* was collected in Haripur District in northern Pakistan. This plant is a small to medium-sized deciduous tree with limited distribution in Pakistan, e.g., the Kurram Valley, Swat, Hazara, Gilgit, Chitral, Muree, Salt range, Peshawar, and Rawalpindi (Pant et al. 2010; Abbasi et al. 2011). Chinese pistachio is traditionally used for treatment of human diseases such as loss of appetite, asthma, coughs, and diarrhea, and leaf galls associated with *Pemphigus* aphids are effective against hepatitis (Bibi et al. 2015).

The rust fungus was determined as a *Pileolaria*. Two *Pileolaria* species, *P. terebinthi* and *P. pistaciae* F.L. Tai & C.T. Wei, have previously been recorded from *P. chinensis* (Teng 1996).

Light microscopy was done on spore mounts embedded in a drop of fixing jelly (glycerine jelly). About 40 randomly chosen spores of each spore state were measured. Our material was identified by uredinial and telial characters as *P. terebinthi*, the first report of this species from Pakistan.

Taxonomy

Pileolaria terebinthi (DC.) Castagne, Observ. Uréd. 1: 22. 1842. Plate 1

Spermogonia and Aecia not found. Uredinia amphigenous on leaves, mostly adaxial, reddish brown; Urediniospores ellipsoid, pyriform or oblong,

Plate 1: *Pileolaria terebinthi* (ISL–9938). A. *Pistacia chinensis* leaves showing abaxial blackish brown pustules; B. Urediniospore with thick wall; C, D. Teliospores and pedicels; E–F. Teliospores and pedicels (SEM), showing single apical germ pore and rugose surface. Scale bars = 10 µm.

brown to yellowish-brown, pedicellate, verruculose, 26–38 × 18–25 µm; wall densely and minutely verruculose, 3–4 µm thick, thickened up to 6 µm apically, germ pores 4 and equatorial. Telia amphigenous on leaves, mostly adaxial, dark-brown, dusty, rounded, sometimes confluent, 0.5–2.5 × 0.3–1.8 mm in diam; Teliospores chestnut or reddish brown, transversely compressed, unicellular, 20–30 × 27–35 µm in size, wall 3–5 µm thick, rugose, chestnut-brown, with a single apical germ pore, covered by a hyaline or pale papilla measuring 2–5 × 5–11 µm; pedicel 50–190 × 7–12.5 µm, hyaline, thick-walled (1.5–4 µm), smooth, persistent.

Material examined: **PAKISTAN, Khyber Pakhtunkhwa**, Hazara Division, District Haripur, altitude 560 m.a.s.l., on *Pistacia chinensis* Bunge (*Anacardiaceae*), stages II & III, December 2014, leg. B. Ali BA76 (ISL–9938).

Comments: *Pileolaria pistaciae* differs from *P. terebinthi* by its longer (30–46 µm), narrower (15–20 µm), irregularly verrucose, more pointed urediniospores

with thinner walls (1.5–2 μm thick laterally, 4–8 μm thick apically) and by its teliospores having shorter (30–50 μm), narrower (5–7 μm), and roughened pedicels (Hiratsuka et al. 1992; Teng 1996).

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Lectotypification of the name *Umbilicaria esculenta*

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Abstract — The protologue and typification of the name *Umbilicaria esculenta* [≡ *Gyrophora esculenta*], an East Asian lichen-forming fungus, are discussed. The lectotype is designated from the Miyoshi collection deposited in TNS.

Key words — iwatake, Japan, lichenised *Ascomycota*, nomenclature, *Umbilicariaceae*

Introduction

Although the family *Umbilicariaceae* has been studied for many years, questions regarding typification remain to be solved (e.g. Wei & Jiang 1993; Jørgensen et al. 1994; Hestmark 2007, 2010, 2014; Davydov et al. 2014).

Umbilicaria esculenta (*Umbilicariaceae*) is characterized by a large rigid thallus with a matte, smooth to rough and particularly schizidiate upper thallus surface; the lower surface is velvet-like due to dense black branched rhizinomorphs with multiseptate (400–500 cells or more) thalloconidia. The distribution of the species is restricted to East Asia (Japan, Korea, Russian Far East, and China), where it grows mostly in forests on steep siliceous rocks in upland areas of the warm temperate region and the lowlands of the cool temperate regions (Satô 1968, Blum 1969, Wei & Jiang 1993, Yoshimura 1993, Moon 1999).

Umbilicaria esculenta is well known in Eastern countries as an edible lichen named "Iwatake" in Japan, "Sheakki" in Korea, and "Shi-er" in China. The species is also used in medicine (e.g., Hirabayashi et al. 1989, Yoshimura 1993 [and references in that paper], Kim & Lee 2006, Wu et al. 2014, Xu et al. 2014).

However, since the name *U. esculenta* has yet to be typified, the purpose of this study is to elucidate its history and to designate its lectotype.

Original material

Prof. Manabu Miyoshi (1862–1939), a Japanese botanist who mainly researched cherries and irises, also collected lichens and published several lichenological papers. In one of these he described *Gyrophora esculenta* (the basionym of *Umbilicaria esculenta*), the first lichen described by a Japanese scientist (Miyoshi 1893). Although the protologue lacks a Latin description and is written in German, the name was validly published according to the ICN (2012: Art. 38.1, 39.1). No specimens are cited in the protologue, but Miyoshi (1893) mentioned that the species is known from "Mts Kiso, Nikko, Kumano u. s. w."; he also referred to its occurrence in his earlier report on a botanical excursion to Mt. Ontake (Miyoshi 1890) but provided no description or diagnosis for this taxon.

Llano (1950) and Wei & Jiang (1993), who did not see the type material of *U. esculenta*, considered the type to be "In the Botanical Institute, Tokyo University, from Japan, leg. Miyoshi" (Llano 1950: 189). Miyoshi's collections, formerly kept in TI (University of Tokyo), are currently deposited in the Herbarium, National Museum of Nature and Science, Tsukuba, Japan (TNS), and we have found only one collection associated with the protologue of *Gyrophora esculenta* in this herbarium. Two other collections possibly belonging to the original material were found in European herbaria and are discussed below.

As imprinted in the protologue, Miyoshi had written his paper in "Leipzig, 15 October 1893", where he researched from 1891 until 1894. The botanical collections of Leipzig, as well as those of Berlin, were mainly destroyed during the Second World War, and most of their lichen collections were lost. Surprisingly, several of Miyoshi's *U. esculenta* specimens are still present in the Herbarium of Botanischer Garten und Botanisches Museum Berlin-Dahlem Freie Universität, Berlin, Germany (B). Four packet labels indicate that Miyoshi bought them in a Tokyo market in Tokyo and provide no additional information. One packet belonging to exsiccata no. 1613 of Arnold (1899) and another labelled "Japan" and "Ded. [Dedit] Miyoshi" may represent original material, but the collecting date is missing on both labels. A copy of the photograph published by Matsumura & Miyoshi (1899) is included with the "Ded. Miyoshi" specimen. Thalli are glued onto a sheet of paper, but some appear to have subsequently been removed; we did not find on the sheet thalli identical to those in the photo. The handwriting on the labels seems to date from the time when Miyoshi was in Germany and may have been written by P. Hennings, then curator of fungi who published a small contribution on

edible fungi of Japan that included *U. esculenta* (Hennings 1899). Probably he obtained these specimens from Miyoshi for an exhibition at the Botanical Museum in Dresden (H. Sipman, pers. comm.). Because there is no precise data (e.g., locality, collector, date) mentioned on the sheet, we cannot be sure if this specimen was part of the original material.

Other collections were found in the herbarium of Botanische Staatssammlung München, Munich, Germany (M). The collection distributed by Arnold as an exsiccata is also presented in M, but only "Japan" is mentioned as the locality, whereas the collection with the barcode label M-0059004 is referred to one of the localities (Nikko) mentioned in the protologue (Miyoshi 1893). The envelope of M-0059004, which has a printed label "ex coll. M. Miyoshi", undoubtedly belongs to Miyoshi's collections. The locality and collector data are handwritten in ink, but the date of collection is missing. It is impossible to say with full confidence whether Miyoshi wrote it; some letters look similar to his handwriting, but the others do not. The second printed label indicates that this specimen belonged to Dr F. Arnold's herbarium and was received in 1901 by M; clearly, Arnold obtained it from Miyoshi earlier, but no additional information documenting this could be found given the absence of correspondence between Miyoshi and Arnold in Arnold's archive in M (A. Beck, pers. comm.). It appears from label data in TNS that Miyoshi's major collecting activity in Nikko was in 1890; only a few additional Nikko collections date from 1891 and 1900. Thus, we can be almost certain that M-0059004 from Nikko was collected before the protologue was published in 1893.

The single *Gyrophora esculenta* specimen in TNS collected by Miyoshi does not have an original label written by Miyoshi but has a label prepared by Dr Masami Satô (Fig. 1). On this blank printed label "Masami Satô" was imprinted as collector and identifier; but then the name of collector was corrected to "Manabu Miyoshi (?)", and the locality "Honshu: Mt. Kiso-Ontake" and date "Aug. 15, 1890" were added (in Japanese) in Satô's handwriting. Satô also studied *Umbilicaria* and in particular he published a paper on *U. esculenta* (Satô 1968). It would be logical to assume that he examined Miyoshi's collection housed in the University of Tokyo (TI). It seems that the original label lacked the precise information on collector, and Satô added "Manabu Miyoshi" because he knew that Miyoshi was collecting at that date in Ontake Mts. This is the only specimen having the collecting data, and its locality was mentioned in the protologue; thus we assume that the TNS specimen most probably belongs to the original material.

Thus, two collections, in M and in TNS seem to belong to the original material. Both collections are morphologically in agreement with the description although, as for that in B, they do not include fertile material.

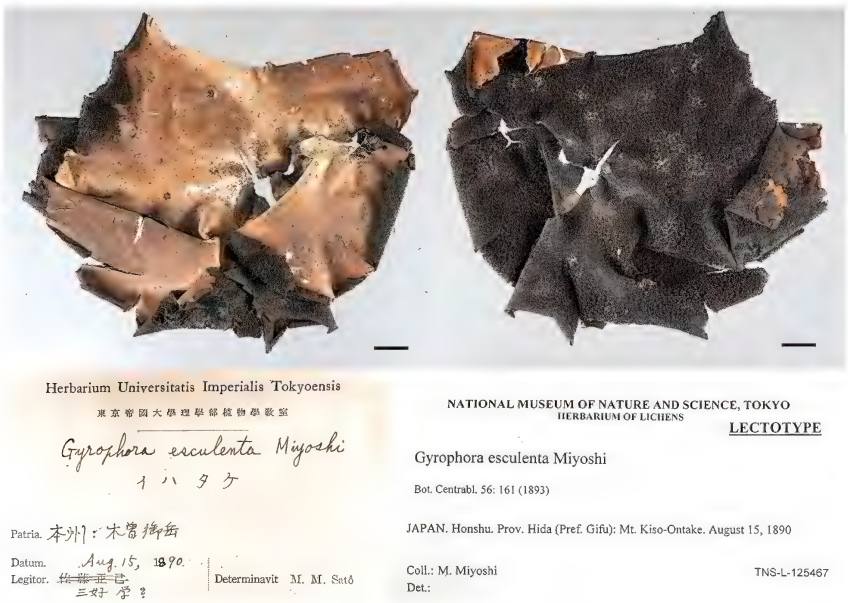

FIGURE 1. *Gyrophora esculenta* (lectotype, TNS-L-125467). Upper (left) and lower (right) surfaces of the specimen; herbarium labels. Scale = 1 cm.

According to the protologue, Miyoshi investigated not only sterile specimens but also fertile material, which is rarely observed in this species. Nevertheless, since the TNS collection has both locality and date, which agree with the data in the protologue, we designate it as the lectotype of *Gyrophora esculenta* (FIG. 1).

Typification

Umbilicaria esculenta (Miyoshi) Minks, Mém. Herb. Boiss. 22: 22. 1900.

≡ *Gyrophora esculenta* Miyoshi, Bot. Centrabl. 56: 162. 1893.

TYPE: Japan. Honshu: Mt. Kiso-Ontake, Aug. 15, 1890, leg. M. Miyoshi s.n. (**Lectotype designated here**, TNS-L-125467).

OTHER ORIGINAL MATERIAL TRACED: Japan. Honshu: Nikko, ex. coll. M. Miyoshi s.n. (M-0059004).

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providing historical information on Arnold's collection in M, to Prof. H. Kashiwadani (National Museum of Nature and Science) and Dr. A. Sennikov (Finnish Museum of Natural History, University of Helsinki) for their valuable comments, and to Prof. M.R.D. Seaward for improving the text.

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Dinemasporium japonicum on *Polytrichum commune* from Korea

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Abstract — *Dinemasporium japonicum* was found growing on the decaying stems of *Polytrichum commune* (*Bryophyta*). The identification of *D. japonicum* was based on its morphological characteristics and the sequence analysis of the internal transcribed spacer of ribosomal DNA. This represents the first record of *D. japonicum* on a non-tracheophyte substrate, and the first record of its occurrence in Korea.

Key words — common haircap moss, ITS rDNA, phylogeny, *Polytrichaceae*

Introduction

Dinemasporium Lév. (*Chaetosphaeriaceae*, *Sordariomycetes*) is characterized by setose conidiomata exposing a slimy conidial mass at maturity, phialidic conidiogenous cells, and hyaline, oblong to allantoid, aseptate conidia with an appendage at each end (Crous et al. 2012; Hashimoto et al. 2015). It is a phylogenetically well-defined genus in the *Chaetosphaeriaceae*, and morphological characteristics such as conidiomatal setae, conidial size, and length of conidial appendages are useful for distinguishing its species (Crous et al. 2012).

In June 2012, mats of common haircap moss (*Polytrichum commune* Hedw., *Polytrichaceae*, *Bryophyta*) were found to be dotted with brown to

purplish brown patches on Mt. Cheongtae located in Hoengseong county in Korea. Careful observation of the discoloration revealed that some of the moss stems and leaves were associated with fungal growth. Decaying mosses were characterized by conidiomata with setae large enough to be visible to the naked eye. A short survey showed that hundreds of the moss plants were decayed by one type of fungus. Here, we identify this fungus as *Dinemasporium japonicum*, based on morphological characteristics and phylogenetic analyses.

Materials & methods

Fungal structures were detached from the moss and placed on a glass slide in a drop of water. Observations were made with an Olympus BX51 microscope (Olympus, Tokyo, Japan) and with a Zeiss AX10 microscope using bright field and differential interference contrast (DIC) light microscopy and an AxioCam MRc5 camera (Carl Zeiss, Göttingen, Germany). At least 30 measurements of each fungal structure were conducted at 100–1000×. A voucher specimen was deposited in the Korea University Herbarium, Seoul, Korea (KUS).

To obtain a pure isolate, the fungal structures with a conidial mass were carefully removed and placed in a drop of sterilized water on a glass slide, since conidial dispersal occurs in water. A loop of conidial suspension was streaked onto 2% water agar plates supplemented with streptomycin sulfate (100 mg/L). After 1–2 days of incubation at 25°C, the conidia began to germinate. Single conidial colonies were transferred onto potato dextrose agar (PDA) using a fine needle. The obtained isolate was deposited in the Korean Agricultural Culture Collection, Wanju, Korea (KACC).

Genomic DNA was extracted from fungal colonies growing on PDA using DNeasy Plant Mini DNA Extraction Kits (Qiagen Inc., Valencia, CA, USA), following the manufacturer's instructions. The complete internal transcribed spacer (ITS) region of rDNA was amplified with the primers ITS1/ITS4 (White et al. 1990) and purified using a QIAquick PCR Purification Kit (Qiagen Inc.). The purified PCR amplicons were directly sequenced using Macrogen Sequencing Service (Macrogen, Seoul, Korea). The newly generated sequence was deposited in GenBank. Several ITS rDNA sequences of *Dinemasporium* species in the NCBI GenBank database were retrieved for the phylogenetic analysis. *Pseudolachnea hispidula* was used as outgroup. Sequences were aligned using MAFFT version 7 (Katoh & Standley 2013). A phylogenetic tree was inferred using the neighbor-joining method in MEGA6 (Tamura et al. 2013), with the default settings of the program. The reproducibility of the internal nodes in the tree was tested by bootstrap analysis using 1000 replications.

Taxonomy

Dinemasporium japonicum A. Hashim., G. Sato & Kaz. Tanaka, Mycoscience 56: 92. 2015 ["2014"]. FIG. 1

Fungal colonies on PDA were flat, ivory to pale yellow, floccose, with sparse aerial mycelium. Conidiomata were stromatic, scattered or aggregated,

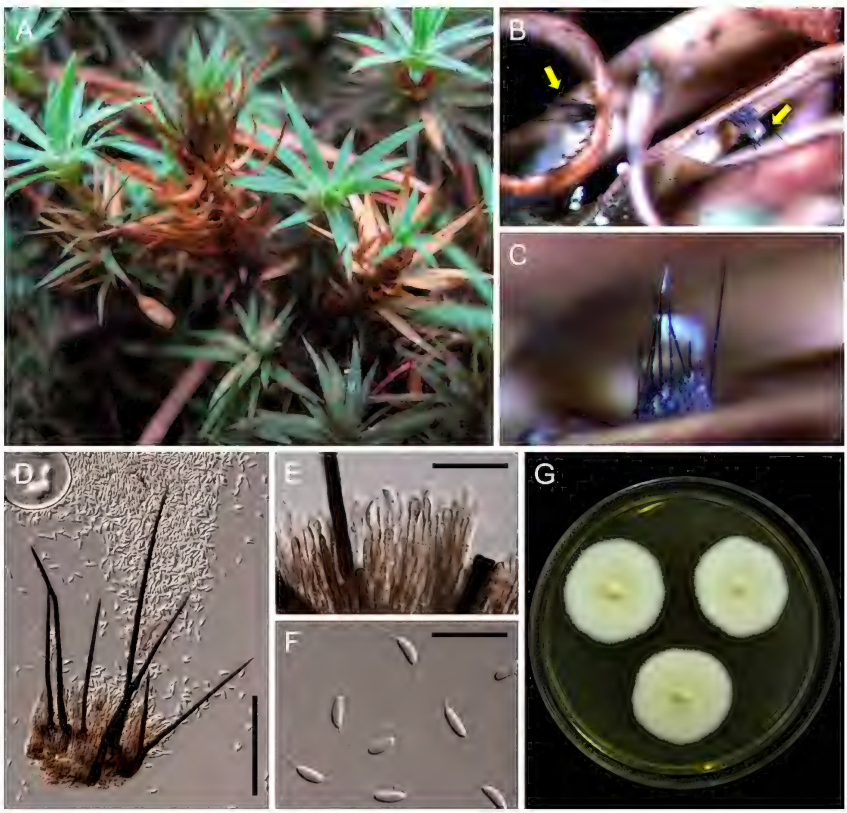

FIG. 1. *Dinemasporium japonicum* on *Polytrichum commune*. A: Discoloration of stems and leaves of the common haircap moss associated with fungal growth. B: Close-up view of leaves, showing fungal structures (arrows). C, D: Conidioma with setae, containing a conidial mass. E: Conidiophores with conidiogenous cells. F: Conidia with two appendages. G: Two-week-old colonies on potato dextrose agar. Scale bars: D = 100 µm; E, F = 20 µm.

superficial, pulvinate, dark brown to black, setose with pale brown conidial mass in center. Setae were mostly marginal or occasionally in conidiomata, stiff, straight, unbranched, dark brown to chestnut brown, pointed, 1–7-septate, attenuate upwards, 70–300 µm long, and 4–12 µm wide at the base. Conidiophores were lining the basal stroma, cylindrical, hyaline, septate, thin-walled, invested in mucus, 22–36 µm long, and 2–3 µm wide. Conidiogenous cells were phialidic, determinate, subcylindrical to lageniform, hyaline, 5–12 µm long, and 2–2.5 µm wide. Conidia were fusiform to allantoid or naviculate, obtuse on both ends, unicellular, hyaline, milky white to pale pinkish in a slimy

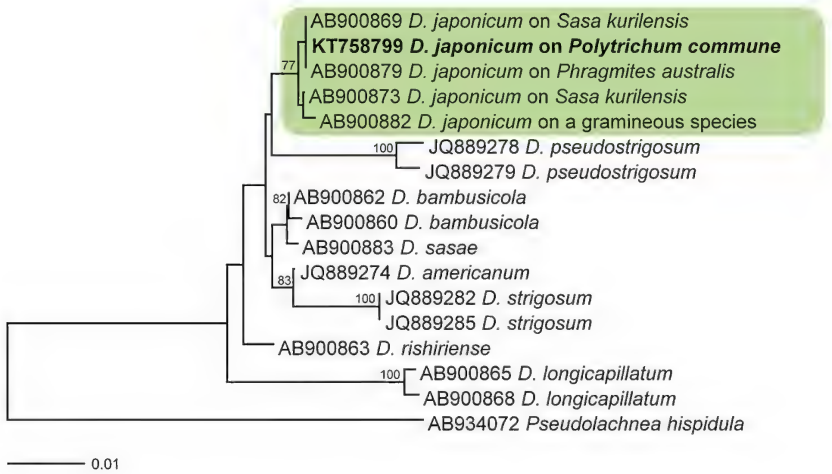

Fig. 2. ITS phylogenetic tree inferred from the neighbor-joining method for *Dinemasporium japonicum* and allied taxa, based on the sequences of the internal transcribed spacer rDNA region. Bootstrap support values from 1000 replicates are shown at the nodes. Our new sequence is indicated by bold font. Scale bar indicates number of nucleotide substitutions per site.

mass, and 6.5–9 µm long, and 2–3 µm wide. Appendages were 7–11 µm long and almost centric.

Specimen examined – **KOREA**, **Gangwon**, Hoengseong, Mt. Cheong Tae, 37°31′19″N 128°17′25″E, on the decaying stems of *Polytrichum commune*, 18 June 2012, H.D. Shin & J.H. Park (KUS-F26722; culture, KACC46848; GenBank KT758799).

Remarks — The lengths of the conidiophores and conidiogenous cells in our study differed somewhat from those given in the original description (conidiophores 4–17 µm, conidiogenous cells 6–21 µm; Hashimoto et al. 2015). In *Dinemasporium* species, the conidiophores are generally much longer than the conidiogenous cells (Duan et al. 2007; Crous et al. 2012). The holotype specimen of *D. japonicum* should be reexamined to clarify the unusual description for this species.

Phylogeny

The sequence obtained from KACC46848 comprised 502 bp. A BLAST search of this sequence revealed 100% identity with sequence AB900869 from the holotype of *D. japonicum* (HHUF30103). Based on the ITS rDNA sequences,

our Korean sequence clustered within the clade of *D. japonicum*, distinct from other *Dinemasporium* species in the neighbor-joining tree (Fig. 2). Previously, the ITS region provided insufficient resolution for the interspecific relationships of most *Dinemasporium* species. In our study and in that of Hashimoto et al. (2015), however, the ITS region clearly discriminates *D. japonicum* from other *Dinemasporium* species and supports it as a separate lineage.

Discussion

Recently, Hashimoto et al. (2015) introduced *D. japonicum* as a new species occurring on some gramineous (*Juncus*, *Miscanthus*, *Phragmites*, *Sasa*) and unidentified woody substrates from Japan. In general, *Dinemasporium* species occur on various herbaceous and woody substrates (Nag Raj 1993); however, they have never been reported on bryophytes. Our Korean specimen represents the first observation of *D. japonicum* on a non-tracheophyte substrate, and the first record of this fungus in Korea.

Two species, *Epigloea pleiospora* in Poland and *Lizonia emperigonia* in Denmark, Poland, and Sweden, have been recorded on *Polytrichum commune* as phytopathogens, and several *Dinemasporium* species have been reported as phytopathogens on various vascular plants (Farr & Rossman 2016). Although we could not evaluate the phytopathological effects of *D. japonicum* on *P. commune*, this fungus is certainly associated with the discoloration and decomposition of the moss.

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Dictyoceratosporella wuzhishanensis sp. nov. from Hainan Province, China

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Abstract—*Dictyoceratosporella wuzhishanensis* is described and illustrated as a new species, from dead stems of an unidentified broadleaf tree in Hainan Province, China. The fungus has single, unbranched conidiophores, each with an integrated monoblastic apical conidiogenous cell producing a dictyoseptate conidium with 2–4 rounded divergent lobes.

Key words—anamorphic fungi, conidial fungi, hyphomycetes, taxonomy

Introduction

Hainan Province (18°10′–20°10′N 108°37′–111°05′E) is an island in southern China. The annual mean temperature is 22–27°C, and the annual precipitation 1000–2600 mm. Wuzhishan National Nature Reserve, in central Hainan, has a typical tropical rainforest climate.

Among our fungal collections from Wuzhishan National Nature Reserve, we found a hyphomycetous specimen that conformed with *Dictyoceratosporella* Y.R. Ma et al.; it is described and illustrated here as a new species, *D. wuzhishanensis*.

Dictyoceratosporella wuzhishanensis J.W. Xia & X.G. Zhang, **sp. nov.** Figs 1, 2

MycoBank MB 817802

Differs from the two previously described *Dictyoceratosporella* species by its larger conidia with 2–4 shorter, wider lobes.

Type: China, Hainan Province: Wuzhishan, dead stems of unidentified broadleaf tree, 22 Apr. 2015, J.W. Xia (**Holotype**, HSAUP H6660; **isotype**, HMAS 245583).

Etymology: in reference to the type locality.

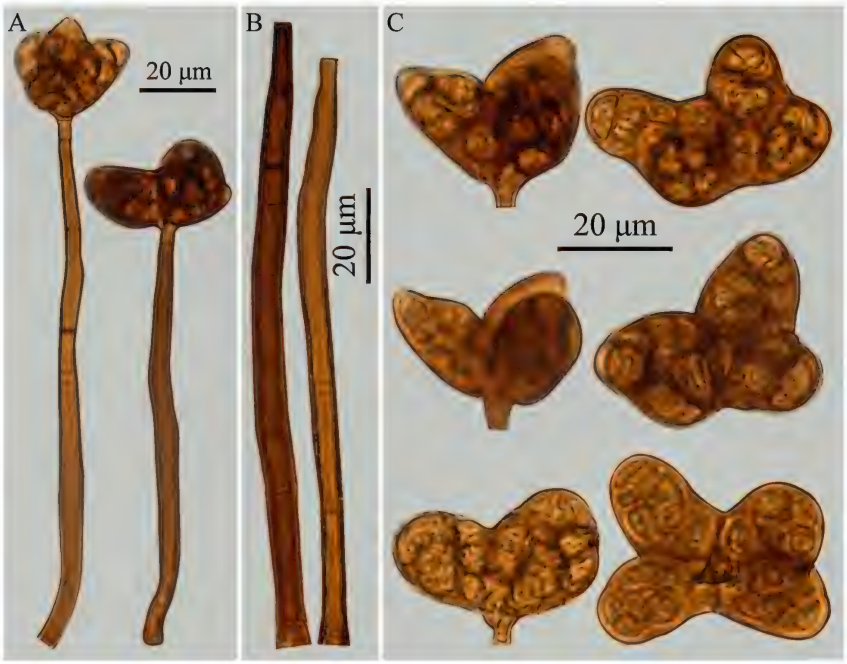

Fig. 1. *Dictyoceratosporella wuzhishanensis* (ex HSAUP H6660):
A. conidiophores, conidiogenous cells, and conidia; B. conidiophores; C. conidia.

Colonies on the natural substrate effuse, brown to dark brown, hairy. Mycelium superficial and partly immersed, composed of septate, pale brown, smooth hyphae, 1–2 μm wide. Conidiophores single, unbranched, erect, straight or slightly flexuous, cylindrical, smooth, thick-walled, brown to dark brown, 6–10-septate, 100–135 × 5–7 μm. Conidiogenous cell monoblastic, integrated, terminal, smooth, cylindrical, brown to dark brown, 15–25 × 3–4.5 μm. Conidial secession schizolytic. Conidia acrogenous, dictyoseptate, solitary, with 2–4 shortly rounded, divergent lobes, smooth, 25–35 μm long and 25–40 μm wide in the middle, rounded at the top; basal cell 3.5–6 × 2.5–3.5 μm, lobes 20–30 × 12–20 μm, with 2–6 transverse septa and 1–3 longitudinal septa.

Comments – The genus *Dictyoceratosporella* was established by Ma et al. (2016) with two species: *D. cordata* Y.R. Ma & X.G. Zhang (type) and *D. limushanensis* Y.R. Ma & X.G. Zhang. It has single, stout, unbranched conidiophores with an integrated apical monoblastic conidiogenous cell producing a dictyoseptate

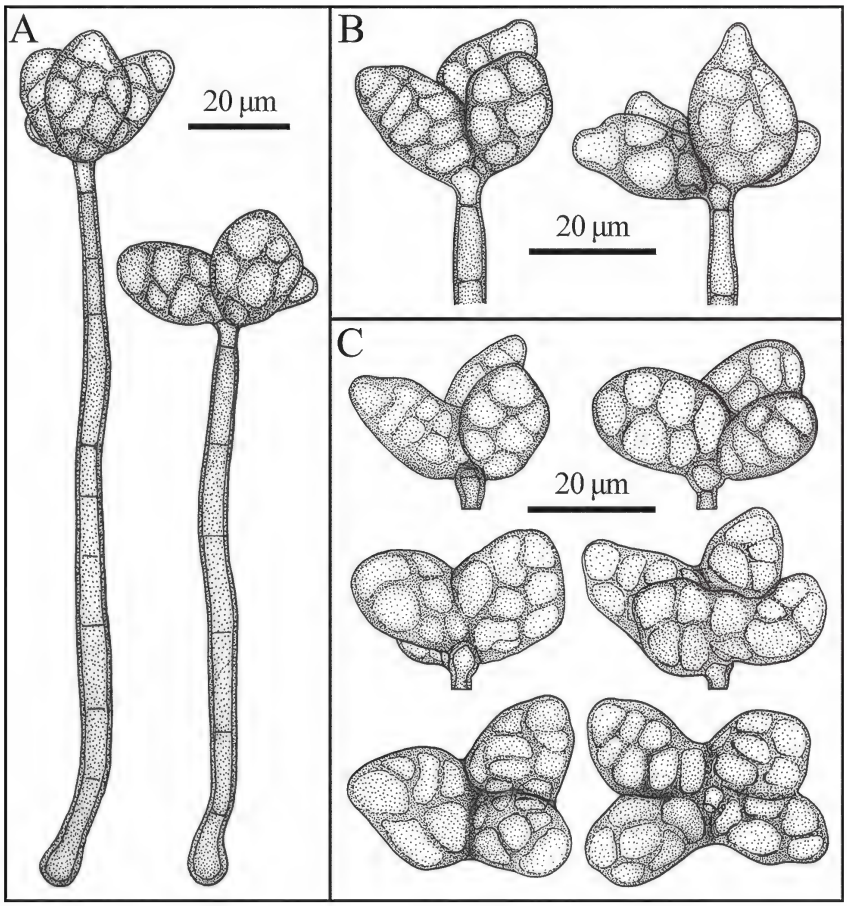

Fig. 2. *Dictyoceratosporella wuzhishanensis* (ex HSAUP H6660):
A. conidiophores, conidiogenous cells, and conidia;
B. conidiogenous cells and conidia; C. conidia.

conidium with 2 or more parallel or divergent arms. Ma et al. (2016) compared *Dictyoceratosporella* with *Actinocladium*, *Ceratosporella*, *Digitoramispora*, *Pseudoacrodictys* and *Triposporium*.

Dictyoceratosporella wuzhishanensis is similar to *D. cordata* in conidial shape. However, the conidia of *D. cordata* have 2(–3) longer, narrower lobes (22–40 × 7.5–15 μm; Ma et al. 2016).

Key to species of *Dictyoceratosporella*

1. Conidia cheiroid, 44–77 × 36–80 µm,
   with 2–5 navicular or fusiform dictyoseptate lobes ..... *D. limushanensis*
1. Conidia bifurcate to cordate 2
2. Conidia 18–44 × 19–36 µm, with an obconic basal cell and
   2(–3) semi-oval dictyoseptate lobes 22–40 × 7.5–15 µm ..... *D. cordata*
2. Conidia 25–35 × 25–40 µm, with a basal cell and
   2–4 semi-oval, dictyoseptate lobes 20–30 × 12–20 µm ..... *D. wuzhishanensis*

Acknowledgments

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Codinaea leomaiae sp. nov. from the Brazilian Atlantic Forest

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Abstract — *Codinaea leomaiae* was collected on the decaying leaf of an unidentified plant and is described and illustrated as a new species. It is distinguished by polyphialidic conidiogenous cells that produce broadly fusiform or eye-shaped, unicellular, hyaline conidia with a single, curved setula at each end. A comparative table and conidial illustrations of some rather similar non-setose *Dictyochaeta* species are also provided.

Key words — asexual fungi, systematics, neotropic

Introduction

Codinaea, introduced by Maire (1937) with *C. aristata* Maire as the type species, is characterized by distinct, single, mononematous or synnematous, brown to pale brown conidiophores and an acerose to subulate, septate, dark brown, thick-walled seta that can be present in some species. The conidiogenous cells are mono- or polyphialidic, terminal, determinate, or indeterminate with a few sympodial extensions and sometimes with enteroblastic percurrent regenerations and with distinct cylindrical or funnel-shaped flaring, sometimes collapsed collarettes at the conidiogenous loci and producing unicellular or

septate, falcate to lunate hyaline conidia with a filiform appendage at each end (Almeida & Gusmão 2014, 2015; Granados et al. 2014; Hughes & Kendrick 1968; Li et al. 2012; Oliveira et al. 2015; Réblová & Winka 2000; Seifert et al. 2011; Xia et al. 2015). For two decades, *Dictyochaeta* (Spegazzini 1923) was considered an earlier name for *Codinaea* for two decades (Gamundi et al. 1977), but following the molecular evidence provided by Réblová & Winka (2000), both genera are currently accepted (Seifert et al. 2011). Li et al. (2012) recommended that species with filiform appendages should be retained in *Codinaea* and taxa lacking appendages placed in *Dictyochaeta*.

During a mycological survey of microfungi associated with leaf litter in a Brazilian Atlantic forest a conspicuous fungus was collected that is described here as a new *Codinaea* species.

Materials & methods

Individual collections were placed in plastic bags, taken to the laboratory, and treated according to Castañeda (2005). Mounts were prepared in polyvinyl alcohol-glycerol (8 g PVA in 100 ml of water, plus 5 ml of glycerol) and in lactic acid (90%), and measurements were made at a magnification of ×1000 under a Nikon Eclipse Ni-U microscope with bright field optics, and photomicrographs were obtained using DIC optics with a Nikon DS-Fi2 camera. The holotype was deposited in the Herbarium, Universidade Federal de Pernambuco, Recife, Brazil (URM).

Taxonomy

Codinaea leomaiae M.A. Barbosa, Malosso & R.F. Castañeda, **sp. nov.** Fig. 1

IndexFungorum IF 551859

Differs from all other *Codinaea* and *Dictyochaeta* species by its polyphialidic conidiogenous cells and broadly fusiform or eye-shaped conidia with a single curved setula at each end.

Type Brazil, Pernambuco, Tamandaré, REBIO Saltinho, 8°43′S 35°11′W, alt. 85 m., on decaying leaf of an unidentified plant, 9.XI.2015, coll. M.A. Barbosa (**Holotype** URM 88249).

Etymology: Latin, *leomaiae*, named in honor to the Brazilian mycologist Leonor Costa Maia for her contribution to the study of fungi in Brazil.

Colonies on the natural substrate, scattered, hairy, black. Mycelium superficial and immersed, composed of septate, branched, brown, smooth-walled hyphae 1–2.5 µm diam. Setae absent. Conidiophores distinct, erect, straight or flexuous, cylindrical, 10–14-septate, dark brown below, pale brown to brown toward the apex, 260–300 × 7–9 µm, smooth. Conidiogenous cells polyphialidic, integrated, 40–50 × 4–5 µm, terminal, indeterminate with few sympodial extensions, pale brown, with 3–6 infundibuliform collarettes, 3.5–5 µm deep, 2—5 µm wide. Conidia broadly fusiform to eye-shaped, guttulate,

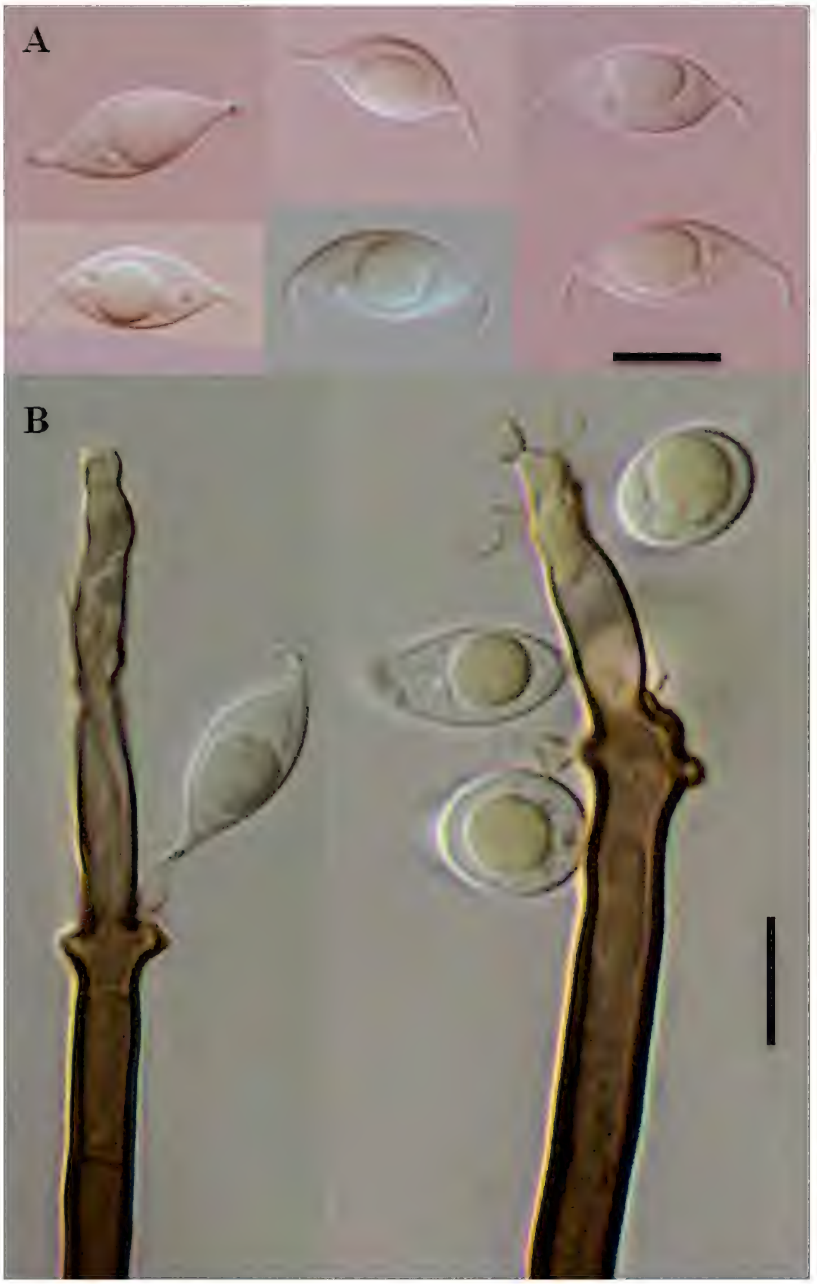

Fig. 1. *Codinaea leomaiae* (ex holotype URM 88249).
A. Conidia. B. Conidiogenous cells and conidia. Scale bars = 10 µm.

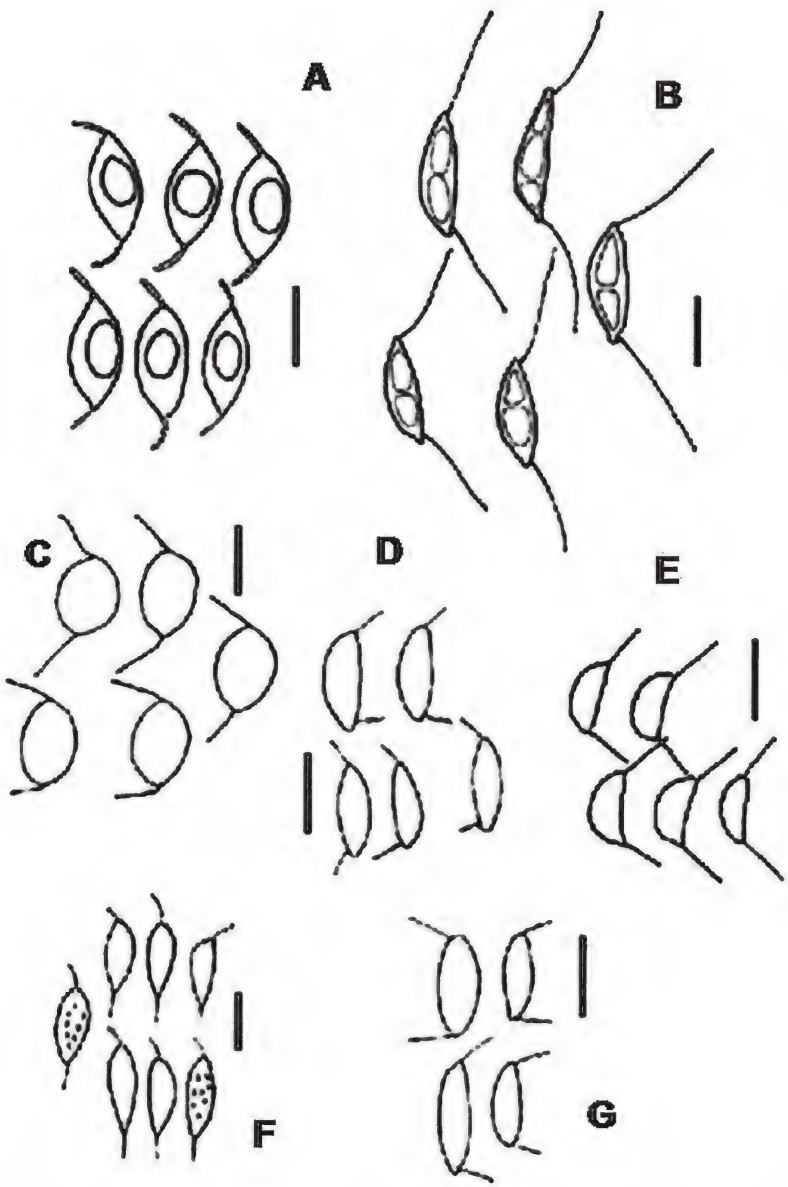

Fig. 2 Conidia of *Codinaea leomaiae* and similar *Dictyochaeta* spp. A. *C. leomaiae*. B. *D. aliformis* (Kuthubutheen & Nawawi 1991). C. *D. ciliata* (Bhat & Kendrick 1993). D. *D. daphnioides* (Kuthubutheen & Nawawi 1991). E. *D. renispora* (Whitton et al. 2000). F. *D. tropicalis* (Bhat & Kendrick 1993). G. *D. tumidospora* (Kuthubutheen & Nawawi 1991). Scale bars = 10 μm.

unicellular, 10–18 × 8.5–9.5 µm, thin-walled, hyaline, smooth, mostly with a filiform appendage at each end forming angles of 45–90°; basal appendage 3.5–5.5 µm long, curved, or rarely slightly curved or straight; apical appendage <6 µm long, curved.

Notes: Among all recorded *Codinaea* and *Dictyochaeta* species (Index Fungorum 2015) only *Dictyochaeta tropicalis* (Bhat & Kendrick 1993) superficially resembles *Codinaea leomaiae*. However, *D. tropicalis* [≡ *Codinaea tropicalis;* Oliveira et al. 2015] has monophialidic, terminal, determinate conidiogenous cells and ellipsoid to drop-shaped conidia, 7.5–9.5 × 3–5 µm with a filiform appendage at each end, with the apical appendage always straight, 2.5—3 µm long and the basal appendage curved, ≤3.5 µm long (Bhat & Kendrick 1993). Other non-setose *Dictyochaeta* species with a single appendage at each conidial end that resemble *C. leomaiae* are *D. aliformis*, *D. daphnioides*, and *D. tumidospora,* which have polyphialidic conidiogenous cells (Kuthubutheen & Nawawi 1991), and *D. ciliata* (Bhat & Kendrick 1993) and *D. renispora* (Whitton et al. 2000) characterized by monophialidic conidiogenous cells. These species are compared and illustrated (Table 1, Fig. 2).

Table 1. Comparison of some non-setose *Codinaea* and *Dictyochaeta* species with a single appendage at each conidial end

Species	Conidia (µm)	Setulae (µm length)	Reference
C. leomaiae	10–18 × 8.5–9.5	<6	This paper
D. aliformis	16–22 × 4–5	18–22	Kuthubutheen & Nawawi (1991)
D. ciliata	6.5–10.5 × 6–8	5–8	Bhat & Kendrick (1993)
D. daphnioides	10–15.5 × 3.5–5	3–5	Kuthubutheen & Nawawi (1991)
D. renispora	6–8.5 × 3–4.5	6–12	Whitton et al. (2000)
D. tropicalis	7.5–9.5 × 3–5	<3.5	Bhat & Kendrick (1993)
D. tumidospora	20–28.5 × 7–9.5	8–10.5	Kuthubutheen & Nawawi (1991)

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Stachybotryna longispiralis sp. nov. from the Brazilian Atlantic Forest

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Abstract — *Stachybotryna longispiralis*, collected on decaying leaves of an unidentified plant, is described and illustrated as a new species characterized by long spirally twisted hyaline setae and monophialidic discrete conidiogenous cells that produce subcylindrical unicellular hyaline conidia. A key to *Stachybotryna* species is provided.

Key words — conidial fungi, asexual fungi, systematics

Introduction

Stachybotryna was introduced by Tubaki & Yokoyama (1971) with *S. columaris* as type species and is characterized by distinct, single, erect, septate, penicillate branched toward the apex, hyaline conidiophores and monophialidic, discrete, determinate conidiogenous cells that produce seriate, cylindrical, fusiform, clavate to ellipsoidal, unicellular, subhyaline or hyaline conidia. *Stachybotryna* resembles *Stachybotrys* Corda in conidial ontogeny and arrangement of the conidiogenous cells in forming a penicillate cluster at the conidiophore tips, but the difference between them is the presence of setae and colorless conidia in *Stachybotryna* (Heredia et al. 2012, Seifert et al. 2011).

During a mycological survey of microfungi associated with leaf litter in a Brazilian Atlantic forest, a conspicuous fungus was collected, described here as a new *Stachybotryna* species.

Materials & methods

Individual collections were placed in plastic bags, taken to the laboratory, and treated according to Castañeda (2005). Mounts were prepared in polyvinyl alcohol-glycerol (8 g PVA in 100 ml of water, plus 5 ml of glycerol) and in lactic acid (90%), and measurements were made at a magnification of ×1000 under a Nikon Eclipse Ni-U microscope with bright field optics, and photomicrographs were obtained using DIC optics with a Nikon DS-Fi2 camera. The holotype was deposited in the Herbarium of Universidade Federal de Pernambuco, Recife, Brazil (URM).

Taxonomy

Stachybotryna longispiralis P.M.O. Costa, Malosso & R.F. Castañeda, **sp. nov.** Figs 1, 2

IndexFungorum IF 551861

Differs from all other *Stachybotryna* species by its long spirally twisted setae and its subcylindrical conidia that are corniform at the base.

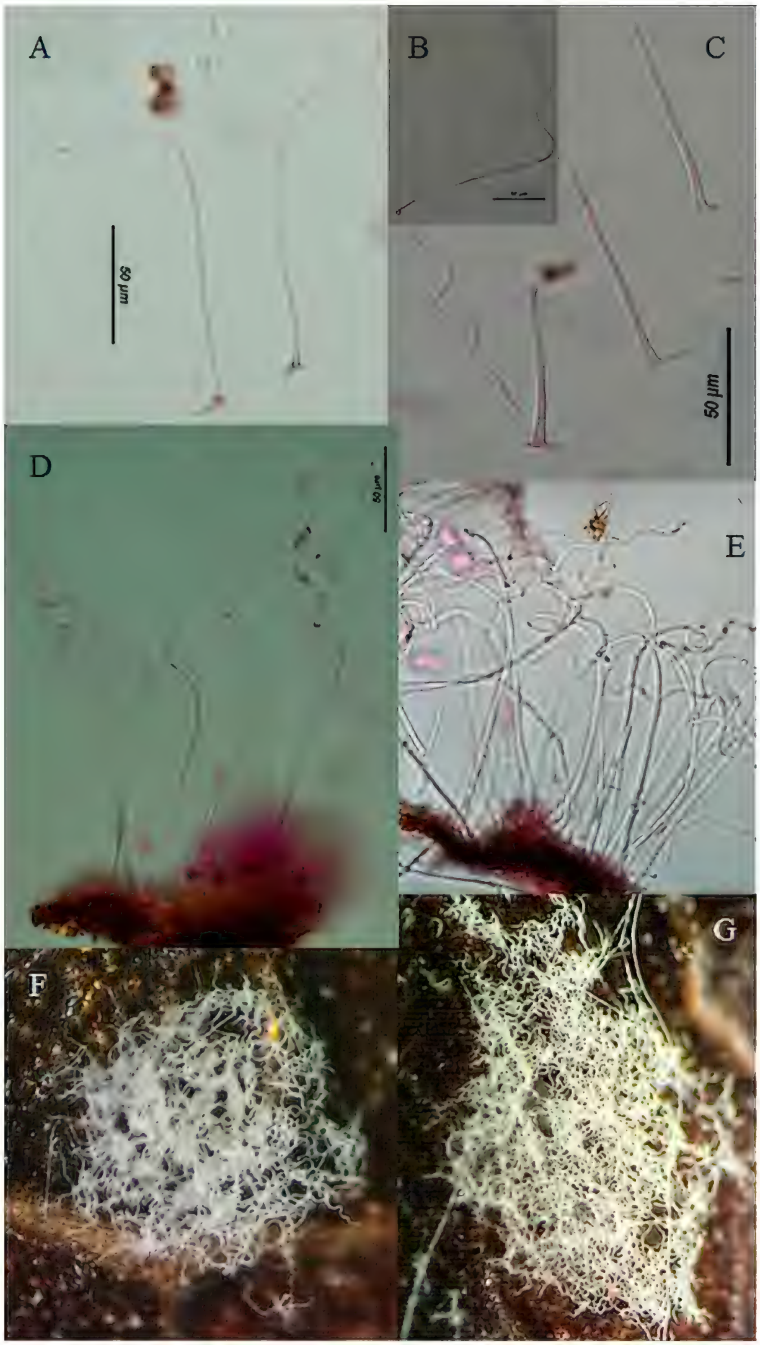
Type Brazil, Pernambuco, Bonito, RPPN Mata da Chuva, 8°30′S 35°42′W, on decaying leaves of an unidentified plant, 7.XI.2015, coll. P.M.O. Costa (**Holotype**, URM 88251).

Etymology: Latin, *longispiralis*, refers to the long spirally twisted setae.

Colonies on the natural substratum densely coiled hirsute, mucous at the middle, amphigenous, white. Mycelium superficial and immersed, composed of septate, branched, hyaline, smooth-walled hyphae, 3–4 µm diam. Setae cylindrical below, long spirally twisted toward the apex, septate, hyaline, smooth, 150–380 µm long, 5–7 µm wide near the base. Conidiophores distinct, grouped near the setae, erect, straight or flexuous, cylindrical, penicillate branched above, 1–3-septate, hyaline, smooth, 30–40 × 7–10 µm, smooth. Conidiogenous cells monophialidic, amygdaliform to inequilaterally lageniform, terminal, discrete, determinate, hyaline, 5–8 × 2–3 µm. Conidia seriate, acrogenous, subcylindrical to subfusiform, corniform at the base, obtuse or slightly rounded at the apex, unicellular, hyaline, smooth, 6–9 × 1–2 µm, forming white, mucous masses.

Notes: In addition to *Stachybotryna columaris* (Tubaki & Yokoyama 1971), four other species have previously been described: *S. splendida* (Castañeda-Ruiz 1987), *S. hachijoensis* (Watanabe 1990) *S. excentrica* (Calduch et al. 2002), and *S. variegata* (Heredia et al. 2012). Only *S. columaris* superficially resembles *S. longispiralis* in conidial shape, but it can be distinguished by its straight or slightly curved setae (each with a long apical cell swollen at the base and a lanceolate, acute apex) and its longer (14–18 × 1.5–2 µm), cylindrical or club-shaped conidia that are slightly flattened at the base (Tubaki & Yokoyama 1971).

Fig. 1. *Stachybotryna longispiralis* (ex holotype URM 88251). A–D. Setae. E, F. Colonies on the natural substrate.


A
50 µm
B
C
50 µm
D
50 µm
E
F
G

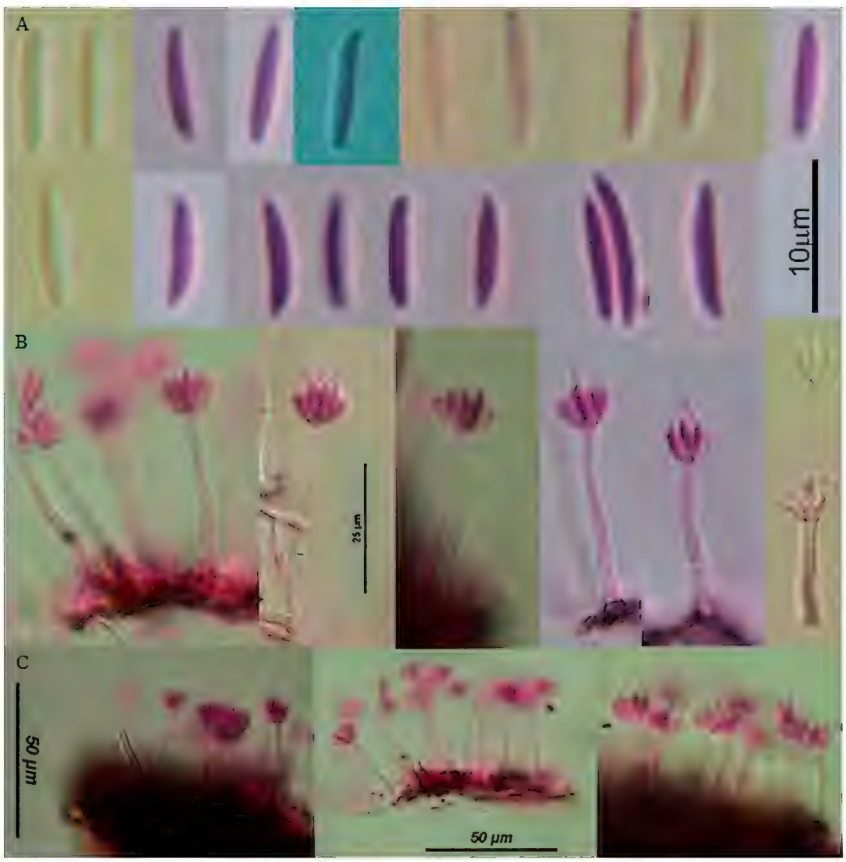


FIG. 2. *Stachybotryna longispiralis* (ex holotype URM 88251). A. Conidia. B, C. Conidiophores, conidiogenous cells, and conidia on the natural substrate.

Key to *Stachybotryna* species

1. Setae spirally twisted; conidia subcylindrical to subfusiform, corniform at the base, 6–9 × 1–2 µm ..... *S. longispiralis*
   Setae not as above 2
2. Setae sometimes or always lanceolate toward the apex 3
   Setae never lanceolate toward the apex 4
3. Setae with apical cell swollen at the base, lanceolate-acute at the apex; conidia cylindrical or club-shaped, flattened at the base, 14–18 × 1.5–2 µm .... *S. columaris*
   Setae lanceolate or clavate at the apex; conidia clavate, ovoid or pyriform, 12.5–27.5(–42) × 5–5.5 µm ..... *S. hachijoensis*

4. Setae entirely colorless, subcylindrical, obtuse at the apex; conidia ellipsoidal to amygdaliform or slightly allantoid, 3.5–5.5 × 1.5–2 µm ..... *S. excentrica*
   Setae somewhat pigmented below 5
5. Setae cylindrical, globose or inflated at the apex; conidia ellipsoidal to ovoid or broadly fusiform, guttulate, 8–10 × 3–4 µm ..... *S. splendida*
   Setae cylindrical, obtuse or rounded at the apex; conidia ellipsoidal to broadly fusiform, 14–18 × 5–6 µm ..... *S. variegata*

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Phaeodactylium cymbisporum sp. nov. from the Brazilian Atlantic Forest

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Abstract — *Phaeodactylium cymbisporum,* collected on decaying leaves of an unidentified plant, is described and illustrated. The new species is characterized by polyblastic, sympodial extended conidiogenous cells that produce broad cymbiform, 3-septate, smooth, pale golden brown conidia. A key to *Phaeodactylium* species is provided.

Key words — conidial fungi, asexual fungi, systematics

Introduction

The genus *Phaeodactylium* was introduced by Agnihothrudu (1968) with *P. venkatesanum* as type species; subsequently, Ellis (1971) synonymised *P. venkatesanum* under *P. alpiniae* [≡ *Dactylium alpiniae* (Sawada 1928)]. *Phaeodactylium* is distinguished by distinct, single, mostly dichotomous branched conidiophores and polyblastic, denticulate, discrete, indeterminate conidiogenous cells with several sympodial extensions that produce solitary, acropleurogenous, clavate to narrowly ellipsoidal, euseptate, subhyaline or hyaline conidia.

During a mycological survey of microfungi associated with leaf litter in a Brazilian Atlantic forest, a conspicuous fungus was collected that is described here as a new *Phaeodactylium* species.

Materials & methods

Individual collections were placed in plastic bags, taken to the laboratory, and treated according to Castañeda (2005). Mounts were prepared in polyvinyl alcohol-glycerol (8 g PVA in 100 ml of water, plus 5 ml of glycerol) and in lactic acid (90%), and measurements were made at a magnification of ×1000 under a Nikon Eclipse Ni-U microscope with bright field optics, and photomicrographs were obtained using DIC optics with a Nikon DS-Fi2 camera. The holotype was deposited in the Herbarium of Universidade Federal de Pernambuco, Recife, Brazil (URM).

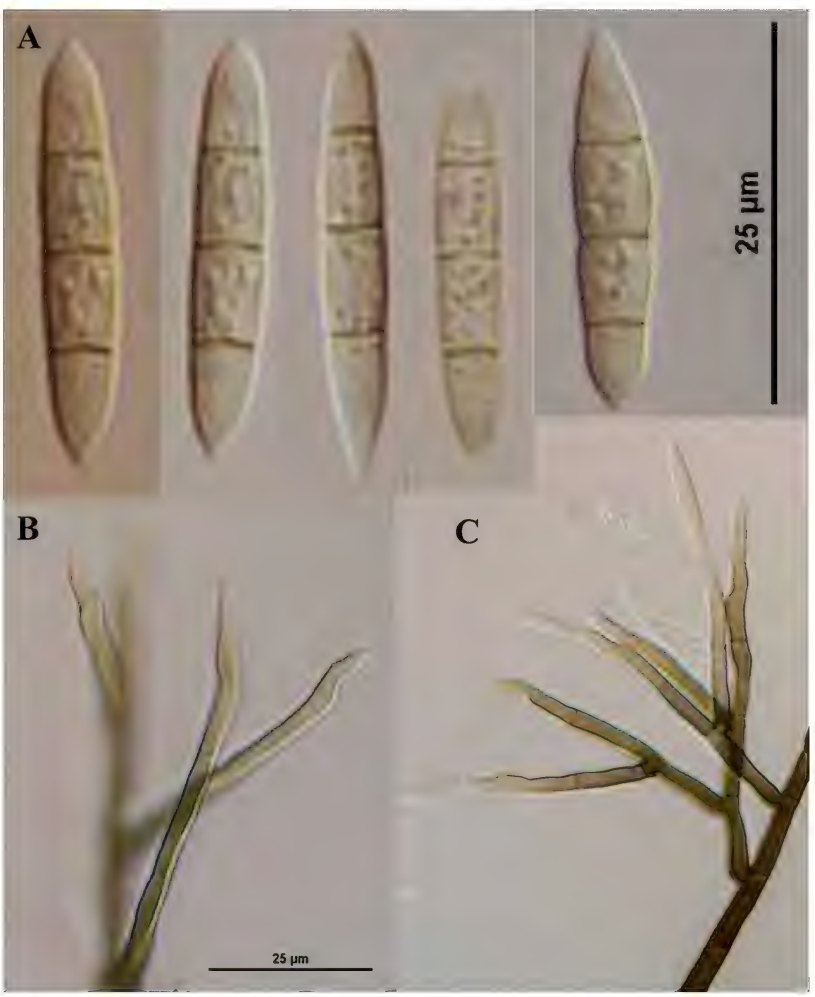

Fig. 1. *Phaeodactylium cymbisporum* (ex holotype URM 88250).
A. Conidia. B, C. Conidiogenous cells and young conidia.

Taxonomy

Phaeodactylium cymbisporum P.M.O. Costa , Malosso & R.F. Castañeda, **sp. nov.** Fig. 1

IndexFungorum IF 551860

Differs from all other *Phaeodactylium* species by its cymbiform, pale golden brown conidia.

Type Brazil, Pernambuco, Bonito, RPPN Mata da Chuva, 8°30′S 35°42′W, on decaying leaves of an unidentified plant, 7.XI.2015, coll. P.M.O. Costa (**Holotype**, URM 88250).

Etymology: Latin, *cymbisporum*, refers to the cymbiform conidial shape.

Colonies on the natural substrate, effuse, hairy, brown to dark brown. Mycelium superficial and immersed, composed of septate, branched, brown, smooth-walled hyphae, 2.5–4 µm diam. Conidiophores distinct, erect, straight or flexuous, cylindrical, dichotomously branched above, ≤15-septate, dark brown below, pale brown toward the apex, 250–400 × 7–10 µm, smooth. Conidiogenous cells polyblastic, denticulate, terminal, in branches incorporated, indeterminate with several sympodial extensions, brown to pale brown, 14–22 × 3 µm. Conidial secession schizolytic. Conidia solitary, acropleurogenous, cymbiform, 3-septate, pale golden brown, smooth, dry, 24–29 × 4–6 µm.

Notes: Among all *Phaeodactylium* species listed in Index Fungorum (2015) and discussed by Castañeda-Ruiz et al. (2009, 2012), Seifert et al. (2011), and Zhang et al. (2011), only *P. alpiniae* (Sawada) M. B. Ellis and *P. curvularioides* Matsush. are superficially similar to *P. cymbisporum* by producing 3-septate conidia. However, these species are clearly differentiated from *P. cymbisporum:* the conidia of *P. alpiniae* are shorter and wider (16–25 × 6–9 µm), ellipsoidal or clavate, and colorless or subhyaline (Ellis 1971) while those of *P. curvularioides* are shorter and wider (13–22 × 5–10 µm) and ovoid (erroneously as "obovoid"; Matsushima 1980) with brown central cells and pale brown or subhyaline end cells (Matsushima 1980).

Key to *Phaeodactylium* species

1. Conidia smooth-walled 2
   Conidia verruculose, obovoid, 1–2-septate, 14–23 × 4–6 µm, subhyaline ..... *P. stadleri**
2. Conidia 2-septate 3
   Conidia 3-septate 4
3. Conidia clavate, fusiform or narrowly ellipsoid, 10–14 × 2–3 µm, with brown central cell and pale brown or subhyaline end cells ..... *P. biseptatum**
   Conidia narrowly ellipsoidal to clavate, 15–20.5 × 5–7.5 µm, pale brown to brown. ..... *P. cephalotaxi**

4. Conidia cymbiform, 24–29 × 4–6 µm, pale golden brown ..... *P. cymbisporum*
   Conidia not cymbiform 5
5. Conidia narrowly ellipsoidal or clavate, 16–25 × 6–9 µm,
   colorless or subhyaline ..... *P. alpiniae**
   Conidia ovoid [not obovoid], 13–22 × 5–10 µm, with brown central cells
   and pale brown or subhyaline end cells ..... *P. curvularioides**

* Castañeda-Ruiz et al. (2009, 2012); Ellis (1971); Matsushima (1980); Zhang et al. (2011).

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Turkish truffles 2: eight new records from Anatolia

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Abstract—Eight truffle taxa are identified as new records for Turkey: two representing *Ascomycota* (*Tuber ferrugineum*, *Tuber puberulum*) and six representing *Basidiomycota* (*Hymenogaster rehsteineri*, *Hysterangium calcareum*, *Leucophleps aculeatispora*, *Melanogaster macrosporus*, *Sclerogaster compactus*, *Sclerogaster hysterangioides*). We also report new localities within Turkey for *Tuber borchii* and *Melanogaster ambiguus*.

Key words—hypogeous fungi, biodiversity, mycota, taxonomy

Introduction

Turkey is among the more botanically rich regions in the northern hemisphere due to diverse elevation gradients and the convergence of three phytogeographical regions: the Euro-Siberian, Mediterranean, and Irano-Turanian (Castellano & Türkoğlu 2012; Türkoğlu & Castellano 2013; Türkoğlu & Castellano 2014). In temperate to subtropical regions, the level of botanical diversity frequently parallels ectomycorrhizal fungal biodiversity including many truffle species. The most common tree families in much of Turkey are predominantly ectomycorrhizal; these include *Betulaceae, Fagaceae, Pinaceae*, and *Salicaceae*. Moreover, many plantations of introduced *Eucalyptus* (*Myrtaceae*) serve as ectomycorrhizal hosts to diverse introduced truffle

species. *Cistaceae* are dominant understory shrubs in Turkish forests and form ectomycorrhiza-like mutualisms with truffle genera including *Terfezia* (Díez et al. 2002, Castellano & Türkoğlu 2012). Sixty truffle taxa have been reported from Turkey (Solak et al. 2007; Sesli & Denchev 2014; Castellano & Türkoğlu 2012; Türkoğlu & Castellano 2013, 2014; Türkoğlu et al. 2015). Here we present eight truffle species identified as new records for Turkey (one each from *Hymenogaster, Hysterangium, Leucophleps,* and *Melanogaster* and two each from *Sclerogaster* and *Tuber*). We also present new localities for the previously reported *Tuber borchii* and *Melanogaster ambiguus*. The biotic and abiotic factors present in Turkey provide ideal habitat for hypogeous fungal diversity; continued study will likely reveal numerous additional taxa.

Materials & methods

Fieldwork was conducted in the Aegean (Aydın, Denizli, Muğla), Black Sea (Artvin, Bolu, Kastamonu, Ordu, Trabzon), Marmara (Tekirdağ, Yalova), and Mediterranean (Antalya, Burdur) regions of Turkey. Specimens were found by raking the soil and carefully examining the exposed area for fruiting bodies (Castellano et al. 2004). The collections were photographed while fresh, and fresh macromorphological features were described (color, shape, size, bruising reactions, odor, and taste). Specimens were then dried and assigned herbarium numbers for further study. Microscope slide mounts were prepared by rehydrating dried material in 3% KOH, Melzer's reagent, or H_2O. Diagnostic micromorphological characteristics were described and photographed by compound microscopy. All collections were given collector (AT–Aziz Türkoğlu) numbers and are deposited in the Truffle Application and Research Center (TARC) of Muğla Sıtkı Koçman University. Fungal names follow Index Fungorum (2014) and MycoBank (2014) and nomenclatural authorities follow Kirk & Ansell (1992).

Taxonomy

Tuberaceae

Tuber borchii Vittad., Monogr. Tuberac. 44, 1831. Fig. 1

Ascocarp subglobose to irregular, 0.5 × 2.5 cm, surface dry, glabrous, occasionally cracked at maturity, paler when young, darkening to brown, rarely with red-brown patches in furrows at basal portion of fruiting body at maturity. Gleba grey when young, becoming dark brown with maturity, marbled throughout with irregularly branching white veins ≤2 mm wide that frequently originate at the peridium; with maturation asci becoming visible with a hand lens as small brown spheres scattered throughout fertile portions of the gleba; odour rich, sweet, strong. Peridium 140–260 µm thick, hyaline, two-layered: outer layer 45–70(–180) µm thick, red-brown, a densely interwoven layer of pigmented cells 6–23 × 8–28 µm, the walls ±1 µm thick, dermatocystidia

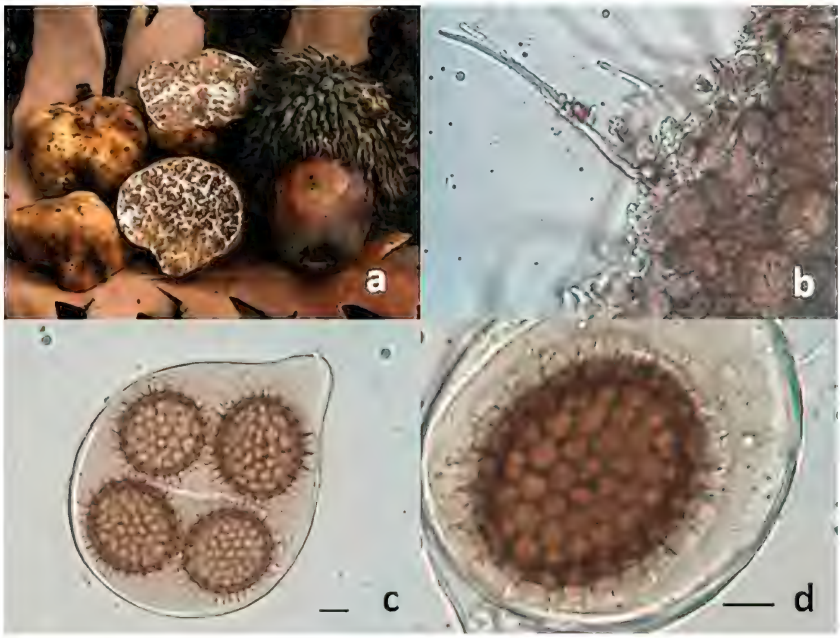

Figure 1. *Tuber borchii* (TARC AT-2253):
a. ascocarp; b. peridium; c. ascus; d. ascospore. Scale bars: c, d = 10 µm.

occasionally present, 64–130 × 4–8 µm wide at base and gradually tapering towards apex; inner layer 130–200 µm thick, of translucent, densely packed inflated cells 6–28 × 8–32 µm, cell walls ±1 µm thick, occasional non-inflated hyphae intermixed. Gleba of tightly interwoven hyphae, 4–13 µm diam, the walls ±1 µm thick, containing scattered oil droplets. Asci subglobose to ellipsoid, 76–99 × 63–85 µm, excluding a stalk ≤18 µm long, tapering towards base, the walls ±1 µm thick, imbedded in the glebal hyphal matrix, 1–4-spored. Ascospores subglobose to ellipsoid, (23–)27–47(–55) × (19–)21–41(–44) µm, mean = 36.6 × 32.4 µm excluding ornamentation [in 1-spored asci 42–55 × 35–42 µm, 2-spored 32–47 × 29–37(–41) µm, 3-spored (23–)26–39(–42) × 21–35 µm, 4-spored 27–37 × 19–31(–33) µm], yellow-brown, ornamentation densely reticulate-alveolate, the alveolae polygonal, 6–10 along the spore axis, red-brown, 4–8 µm tall regardless of spore size.

Specimens examined—**TURKEY, Tekirdağ**, Saray, Ergene district, under mixed stands of *Pinus nigra*, *Quercus* sp., and *Carpinus betulus*, 22 Nov 2013, Türkoğlu AT-2203. **Muğla**, Fethiye, Çenger, under mixed stands of *Quercus cerris, Q. pubescens* and *Pinus brutia,* 9 Mar 2014, Türkoğlu AT-2253; Türkoğlu AT-2266; Fethiye, Gökben,

under *Q. cerris*, 9 Mar 2014, Türkoğlu AT-2258; Ula under mixed stands of *Pinus brutia* and *Quercus coccifera*, 22 Mar 2014, Türkoğlu AT-2296. **Aydın**, Kuşadası, Dilek peninsula, under mixed stands of *Quercus ilex* and *Pinus brutia*, 19 Mar 2014, Türkoğlu AT-2281; Kuyucak, İğdecik, under mixed stands of *Quercus cerris* and *Q. ithaburensis*, 19 Mar 2014, Türkoğlu AT-2286. **Samsun**, Çarşamba, under *Corylus* spp, İsa Şahin, 23 December 2014, Türkoğlu AT-2416.

Remarks—*Tuber borchii* was previously recorded from Kahramanmaraş, Turkey, by Kaya (2009).

Tuber ferrugineum Vittad., Monogr. Tuberac. 46, 1831. Fig. 2

Ascocarp globose to subglobose or irregular, ≤2.2 cm broad, light yellow brown when young, becoming red-brown by maturity, several prominent white furrows present on surface, peridium in cross-section ± 0.1 cm thick, paler in colour than outer surface. Gleba firm, white to pale grey, marbled with irregular white veins, odour pleasant. Peridium 215–390 µm thick, two-layered: outer layer 15–50 µm thick, of red-brown, densely interwoven, pigmented hyphae 1–4 µm broad, the walls ±1 µm thick; inner layer 200–350 µm thick, of translucent,

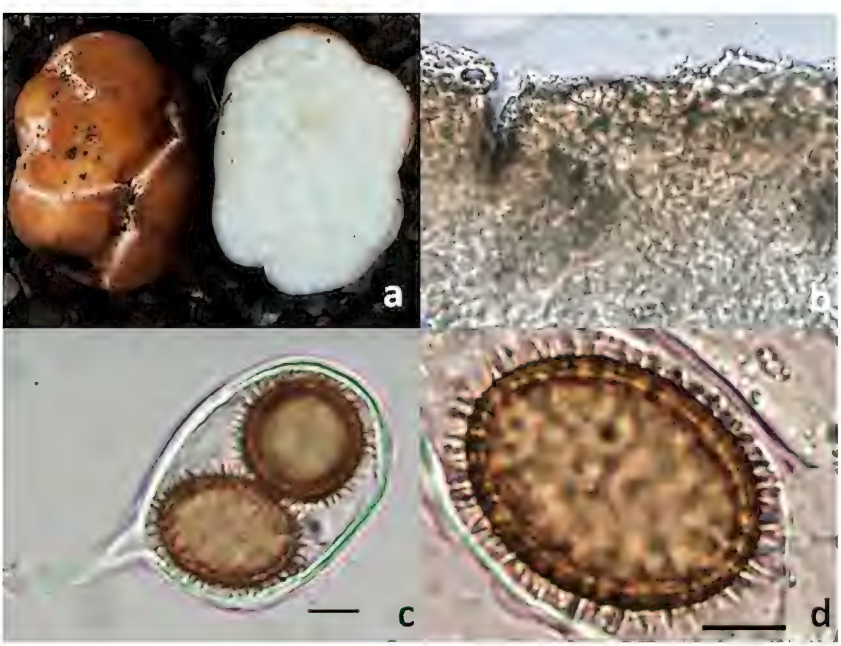

Figure 2. *Tuber ferrugineum* (TARC AT-2279):
a. ascocarp; b. peridium; c. ascus; d. ascospore. Scale bars: c, d = 10 µm.

densely interwoven hyphae 1–4 µm broad, the walls ±1 µm thick, becoming slightly less dense where glebal and peridial hyphae converge. Gleba of hyaline, interwoven hyphae 3–5 µm diam, with infrequent oil droplets, the walls ±1 µm thick. Asci ellipsoid to ovoid, occasionally pyriform, 60–75 × 35–50 µm excluding stalk ≤30 µm long and tapering towards base, the walls ±3 µm thick, embedded in the glebal hyphal matrix, typically 1–4(–5)-spored. Ascospores ellipsoid, 18–43 × 15–29 µm, mean = 28.2 × 20.5 µm excluding ornamentation [in 1-spored asci 29–43 × 21–29 µm, 2-spored 24–37 × 20–26 µm, 3–spored 19–24 × 15–19 µm, 4-spored 21–28 × 15–19 µm, 5-spored 18–23 × 16–19 µm], yellow-brown, densely ornamented with narrow spines 2–4 µm tall.

Specimens examined—**TURKEY, Aydın**, Kuşadası, Dilek peninsula, under mixed stands of *Quercus ilex* and *Pinus brutia*, 19 Mar 2014, Türkoğlu AT-2279. **Muğla**, Campus of Muğla Sıtkı Koçman University, under mixed stands of *Pinus brutia* and *Quercus coccifera*, 30 Apr 2014, Türkoğlu AT-2321. **Denizli**, Serinhisar, Yatağan, under mixed stands of *Pinus brutia, Quercus coccifera* and *Q. ithaburensis*, 8 May 2014, Türkoğlu AT-2332. **Antalya**, Akseki, under *Tilia* sp., 31 May 2014, Esra Er AT-2373.

Tuber puberulum Berk. & Broome. Ann. Mag. Nat. Hist. 18: 81, 1846. Fig. 3

Ascocarp globose to subglobose, ≤0.6 cm tall × 1.5 cm broad, off-white to yellowish becoming pale to yellow-brown, sometimes pale pinkish, surface dry and pubescent. Gleba grey when young, becoming dark brown by maturity, marbled with irregular white veins ≤1 mm broad, originating at the peridium and spreading throughout the gleba, at maturity asci become visible with a hand lens as small brown spheres scattered throughout fertile portions of the gleba. Peridium 110–365 µm thick, white in cross-section, outer edge pale reddish, a single layer of tightly, interwoven hyphae 4–10 µm broad, cell walls ±2 µm thick, with crowded dermatocystidia 5–8 µm wide at base and gradually tapering towards apex, ≤118 µm tall, the walls ±1 µm, emerging from the peridial surface to create a distinctive turf of hyphal tips. Gleba of interwoven hyphae 5–10 µm broad, walls ±1 µm thick, slightly more inflated than those of the peridium, oil droplets frequently present. Asci subglobose to ellipsoid, 65–80 × 65–90 µm, embedded in gleba tissue, typically sessile, the walls ±2 µm thick, 1–4-spored. Ascospores subglobose to ellipsoid, 25–48 × 23–44 µm, mean = 37.6 × 33.1 µm excluding ornamentation [in 1-spored asci 46–48 × 40–44 µm, 2-spored 34–50 × 29–41 µm, 3-spored 25–42 × 23–35 µm, 4-spored 26–35 × 24–29 µm], yellow-brown; ornamentation reticulate-alveolate, meshes polygonal, 6–8(–11) along the axis, red-brown, 5–7 µm tall.

Specimens examined—**TURKEY, Denizli,** Buldan, Süleymanlı, under mixed stands of *Pinus brutia, Quercus cerris* and *Q. ilex*, 17 Dec 2013, Türkoğlu AT-2111; Serinhisar, Yatağan, under mixed stands of *Pinus brutia, Quercus coccifera* and *Q. ithaburensis*,

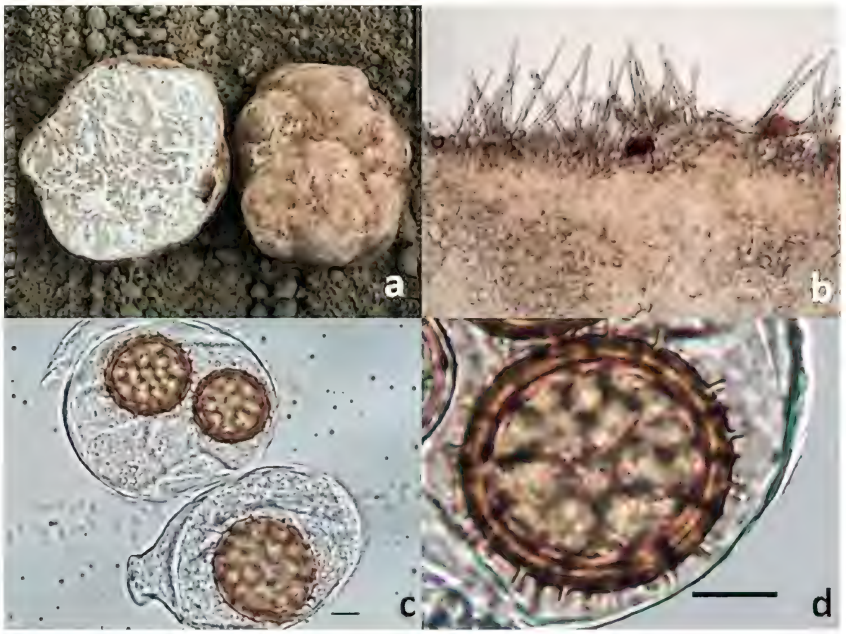

Figure 3. *Tuber puberulum* (TARC AT-2257):
a. ascocarp; b. peridium; c. ascus; d. ascospore. Scale bars: c, d = 10 µm.

21 Mar 2014, Niyazi Uluçoban AT-2294; 8 May 2014, Niyazi Uluçoban AT-2330; Baklan, under *Quercus coccifera* and *Q. trojana*, 18 May 2014, Niyazi Uluçoban AT-2353; Acıpayam, Şahman yaylası *Pinus* spp., and *Quercus* spp., 5 Jun 2014, AT-2388. **Muğla**, Fethiye, Gökben, under *Quercus cerris*, 9 Mar 2014, Türkoğlu AT-2257; Campus of Muğla Sıtkı Koçman University, under mixed stands of *Pinus brutia* and *Quercus coccifera*, 30 Apr 2014, Türkoğlu AT-2322; Dalaman, Çöğmen, 14 Apr 2015, AT-2481; **Aydin**, Kuyucak, İğdecik, under mixed stands of *Quercus cerris* and *Q. ithaburensis*, 19 Mar 2014, Türkoğlu AT-2287. **Osmaniye**, Kaypak köyü, *Pinus* spp. and *Quercus* spp. 27 Apr 2015, Fatih Kaya AT-2491.

Albatrellaceae

Leucophleps aculeatispora Fogel. Can. J. Bot. 57: 1727, 1979. Fig. 4

Basidiocarp irregularly subglobose to lobate, 1.4 × 2 cm, surface at first white to off-white to partly pale yellow becoming yellow-brown, basal mycelia prominent. Gleba white. Peridium 160–220 µm thick, pale yellow to yellow-brown, of loosely interwoven hyphae 2–6 µm broad, the walls ± 1 µm thick. Trama 50–110 µm thick, of hyaline to pale yellow, compactly interwoven hyphae 2–3 µm broad, the walls ± 1 µm thick, droplets scattered within the

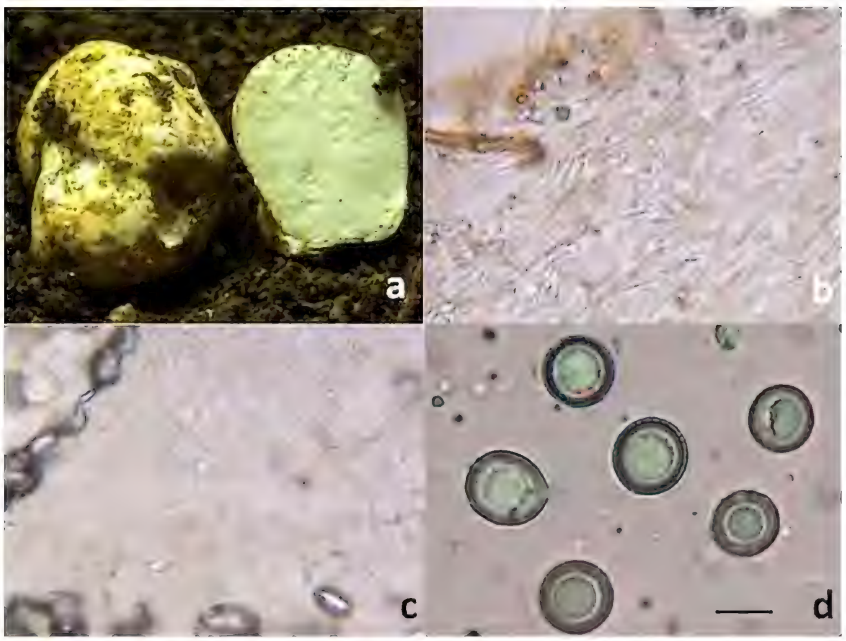

Figure 4. *Leucophleps aculeatispora* (TARC AT-2195):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

hyphae. Basidia not observed. Spores globose or slightly ovoid, 11.4–13.5 × 11.0–12.7(–13.3) µm, mean 12.6 × 11.8 µm, white, ornamented with crowded, minute spines embedded in a mucilaginous matrix.

Specimens examined—**TURKEY, Kastamonu**, Küre, under *Abies nordmanniana* var. *bornmuelleriana* and *Fagus orientalis*, 11 Nov 2013, Türkoğlu AT-2195; Türkoğlu AT-2196; Türkoğlu AT-2197.

Hysterangiaceae

Hysterangium calcareum R. Hesse, Hypog. Deutschl. 1: 97, 1891. Fig. 5

Basidiocarp globose to subglobose, often lobate, 1 × 1.5 cm broad, basal mycelia prominent, surface white to off-white and covered by numerous hyphae and fine rhizomorphs. Gleba dark green, the columella cartilaginous-translucent. Peridium 300–400 µm thick, of hyaline to pale yellow, loosely interwoven hyphae 2.2–9 µm broad with cells inflated ≤20 µm, the walls ±1 thick. Trama 40–100 µm thick, of hyaline, chaotically interwoven to subparallel hyphae in a gelatinized matrix, 2–3 µm broad, the walls ±1 µm thick. Basidia cylindrical to subclavate, 7–10 × 25–45 µm, hyaline, 1–3-spored. Spores

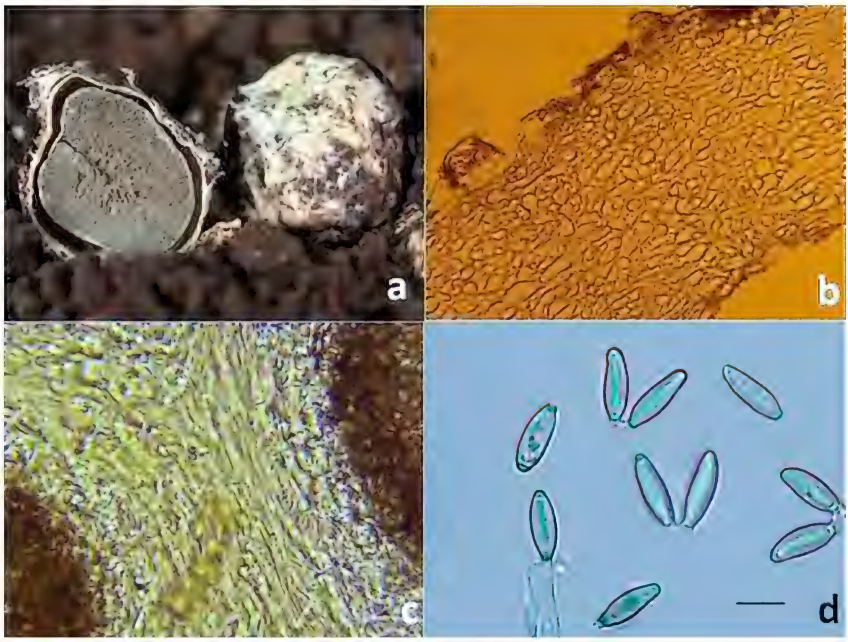

Figure 5. *Hysterangium calcareum* (TARC AT-2176):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

fusiform, 13.1–16.3 × 4.8–6.3 µm, mean 14.0 × 5.0 µm, the walls ±1 µm thick, hyaline to pale green, smooth, sterigmal appendage 1.5–2.5 × 2.5 µm.

Specimen examined—**TURKEY, Ordu**, Ünye, Çaybaşı, under pure *Fagus orientalis*, 27 Oct 2013, Türkoğlu AT-2176.

Paxillaceae

Melanogaster ambiguus (Vittad.) Tul. & C. Tul. Ann Sci. Nat., Bot., sér. 2 19: 378, 1843. Fig. 6

This specimen was found in tailings of an animal dig, so many morphological diagnostic characteristics were damaged, forcing us to base the description on sub-par material. Remnants of basidiocarp black-brown due to having been bruised, 0.6 × 1 cm. Peridial fragment surfaces irregular with shallow pits. Gleba sterile portions dark brown, locules irregular, black. Peridium 50–220 µm thick, single-layered, of red brown compactly interwoven hyphae 3–6 µm broad, the walls 1 µm thick. Trama 80–120 µm thick, reddish grey, of interwoven hyphae 3–5 µm broad, the walls ±1 µm thick. Basidia not observed.

Figure 6. *Melanogaster ambiguus* (TARC AT-2255):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

Spores ellipsoid-citriform-papillate, 13–16 × 7–10 µm, mean 14.4 × 9.0 µm, the walls ±1 µm thick, brown, smooth; sterigmal appendage 2.5–3 × 2 µm.

Specimen examined—**TURKEY, Muğla,** Fethiye, Çenger, under mixed stands of *Quercus cerris, Q. pubescens* and *Pinus brutia*, 9 Mar 2014, Todd Elliott AT-2255.

Remarks—*Melanogaster ambiguus* was previously recorded from Hakkari, Turkey, by Uzun et al. (2014)

Melanogaster macrosporus Velen. České Houby 4–5: 808, 1922. Fig. 7

Basidiocarp subglobose to lobate, 1.5 × 2 cm, surface red-brown with dark brown rhizomorphs. Gleba black at maturity with sterile white veins scattered throughout. Peridium 85–315 µm thick, single-layered, of interwoven hyphae 4–12 µm broad, the walls 1–2 µm thick, red-brown on outer portion of peridium becoming hyaline towards gleba. Trama 120–200 µm wide, opaque, of tightly packed, interwoven hyphae 2–5 µm broad in a gelatinous matrix, the walls ±1 µm thick. Basidia not observed. Spores elongate-fusiform, 10–14 × 5–6 µm, mean 11.5 × 5.7 µm, brown, walls 0.5 µm thick, smooth.

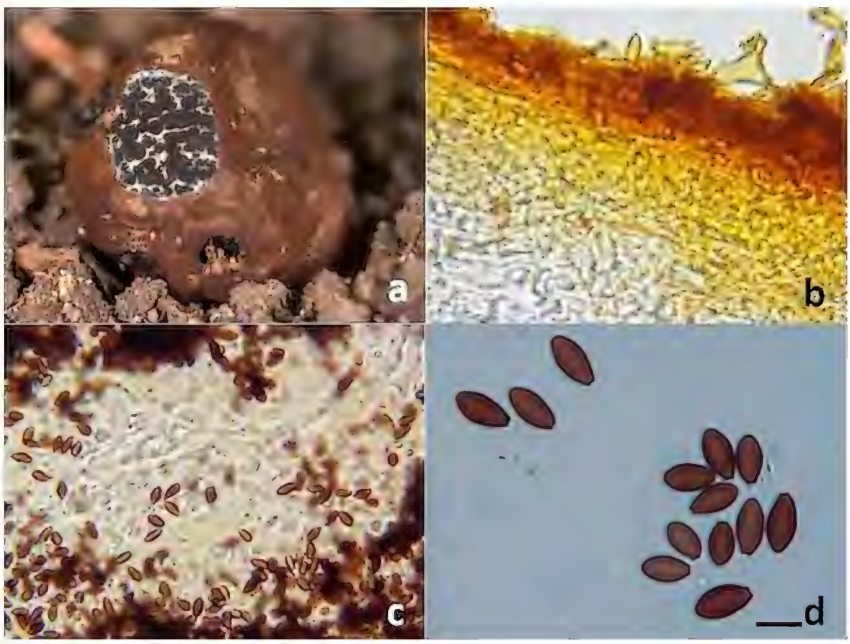

Figure 7. *Melanogaster macrosporus* (TARC AT-2179):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

Specimen examined—**TURKEY, Trabzon,** Sürmene, Aksu village, under *Fagus orientalis, Picea orientalis, Castanea sativa* and *Rhododendron ponticum*, 27 Oct 2013, Türkoğlu AT-2179.

Sclerogastraceae

Sclerogaster compactus (Tul. & C. Tul.) Sacc. Syll. Fung. 11: 170, 1895. Fig. 8

Basidiocarps subglobose to ellipsoid, ≤0.8 × 1 cm broad, white, becoming yellowish with age, dry, the outer layer frequently peeling in fine fibrils to expose the outer gleba, occasional white rhizomorphs present at base. Gleba yellowish-orange with a white columella ±1 mm broad, with white veins radiating outwards. Odour sweet, pleasant, sometimes cheese-like. Peridium 300–600 µm thick, white in cross section, two-layered, separable, the outer layer 170–480 µm thick, dextrinoid in mass, composed of tightly interwoven hyphae 1–3 µm broad, frequently projecting ≤25 µm from outer peridial wall, the cell walls ±1 µm thick; inner peridial layer 100–250 µm thick, consisting of

tightly interwoven, inamyloid hyphae 2–5 µm broad with walls ±1 µm thick; straight hyphae >200 µm long interspersed throughout the tightly interwoven hyphae, easily observable if the peridium is peeled from the sporocarp, occasional inflated cells 13–27 × 11–12 µm typically present towards the gleba, the cell ±1 µm thick. Trama 18–200 µm broad, of interwoven hyphae 2–3 µm diam with occasional inflated cells ≤9–11 × 11–18 µm, the walls ±1 µm thick. Basidia infrequently visible, cylindric to clavate, ± 5 µm broad at apex and tapering towards base, 2–4 spored, sterigmata ≤3 µm long, ±0.5 µm broad. Spores spherical to ovoid, 5–7 × 4–6 µm, mean 6.2 × 5.2 µm, cyanophilic with lactophenol cotton blue, apiculus ≤1.5 µm broad, ornamentation ± 0.5 µm.

In mixed stands of *Pinus brutia* and *Quercus coccifera* in an area with numerous small animal diggings; small tooth-marks appeared on the peridial surface and into the outer gleba of several fruiting bodies.

Specimens examined—**TURKEY, Muğla**, Datça, 25 Oct 2013, Cansu Korkmaz AT-2223; Köyceğiz, Yuvarlakçay, under *Pinus brutia* and *Quercus coccifera*. 8 Mar 2014, Todd Elliott AT- 2252.

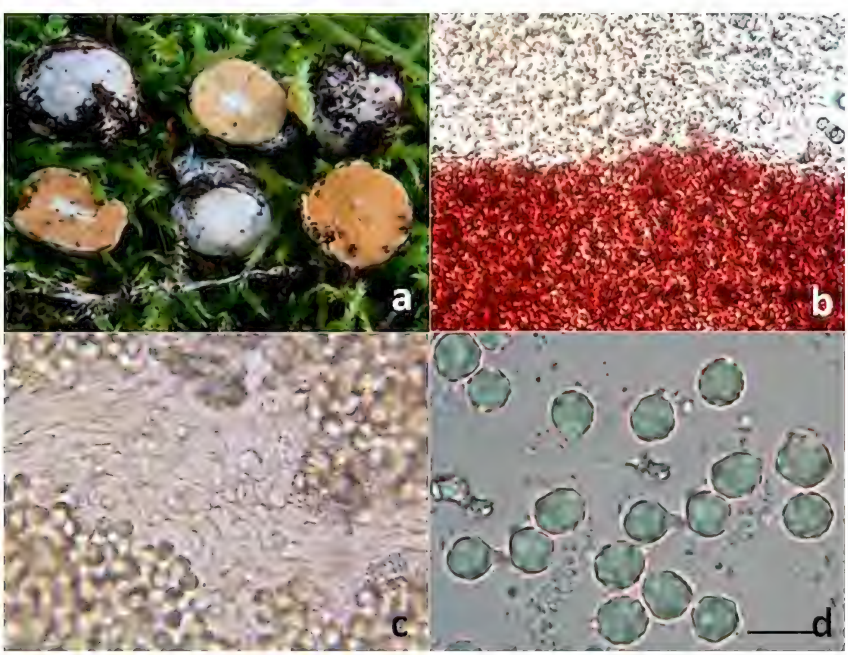

Figure 8. *Sclerogaster compactus* (TARC AT-2252):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

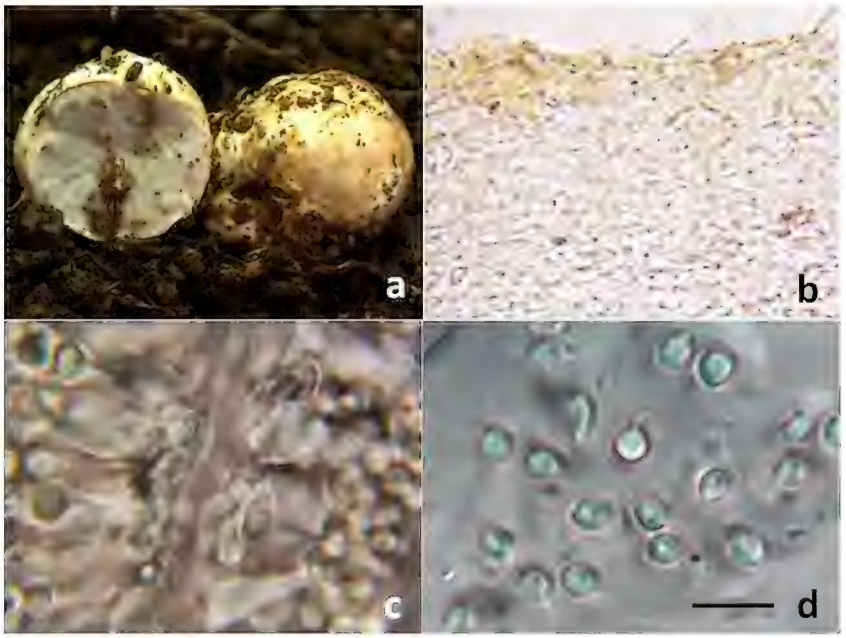

Figure 9. *Sclerogaster hysterangioides* (TARC AT-2187):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

Sclerogaster hysterangioides (Tul. & C. Tul.) Zeller & C.W. Dodge, Ann. Missouri Bot. Gard 22: 370, 1935. Fig. 9

Basidiocarp globose to subglobose, ≤1 × 1.5 cm, white to off white with some pink patches, different colored hyphae present on outer peridial surface, typically brown on basal portion of fruiting body. Gleba off-white when young, turning grey with maturity, columella present at basal portion, ≤2 mm diam at base and tapering towards the center of fruiting body. Peridium 240–410 µm thick, white in cross section, two layered: outer layer 25–80 µm thick, faintly dextrinoid, parallel to loosely interwoven, hyphae 1–4 µm broad with walls ±1 µm thick; inner layer 215–330 µm thick, densely packed interwoven hyphae 3–7 µm broad, the walls ±1 µm thick, inflated cells 4–22 × 3–12 µm, interspersed with inner peridial hyphae, inflated cells. Trama 9–60 µm thick, of loosely interwoven hyphae 2–4 µm broad, the cell walls ±1 µm thick, the locules irregularly shaped up to 180 µm across, clearly demarcated from trama hyphae, lined with basidia and basidiospores. Columella ≤530 µm diam at basal end and tapering towards glebal center, consisting of hyaline parallel hyphae, 0.5–2 µm broad, with occasional interspersed inflated cells 10–14 × 6–8 µm, the walls ±1 µm thick. Basidia clavate to pyriform, 15–18 × 4–6 µm, basidial

walls ±1 µm thick, 3–4-spored, sterigmata 2–5 × 1 µm, tapering towards apex. Spores spherical to ovoid, 4–5 × 3–4 µm, mean 4.6–3.7 µm, faintly cyanophilic with lactophenol cotton blue, smooth to minutely ornamented, apiculus ≤1.5 µm broad.

Specimen examined—**TURKEY, Bolu**, Mengen, Ahmetler Village, under mixed stands of *Pinus nigra* and *Quercus* sp., 9 Nov 2013, Türkoğlu AT-2187.

Hymenogastraceae

Hymenogaster rehsteineri Bucholtz, Hedwigia 40: 318, 1901. Fig. 10

Basidiocarp globose to irregular, 0.8 × 1 cm, the surface smooth, white at first, darkening with age. Gleba overall white (immature specimen), frequently with darker areas, locules irregular, <0.5 mm broad. Peridium 140–275 µm thick, single-layered, the outer part pale yellowish-brown grading to hyaline towards the gleba, of compact parallel hyphae 3–7 µm broad, the walls ±1 µm thick. Trama 60–100 µm wide, of compact parallel hyphae 1–4 µm broad, the walls ±1 µm thick; subhymenium of indistinguishable interwoven hyphal masses giving rise to basidia. Basidia clavate, 4–6 µm broad at the apex tapering

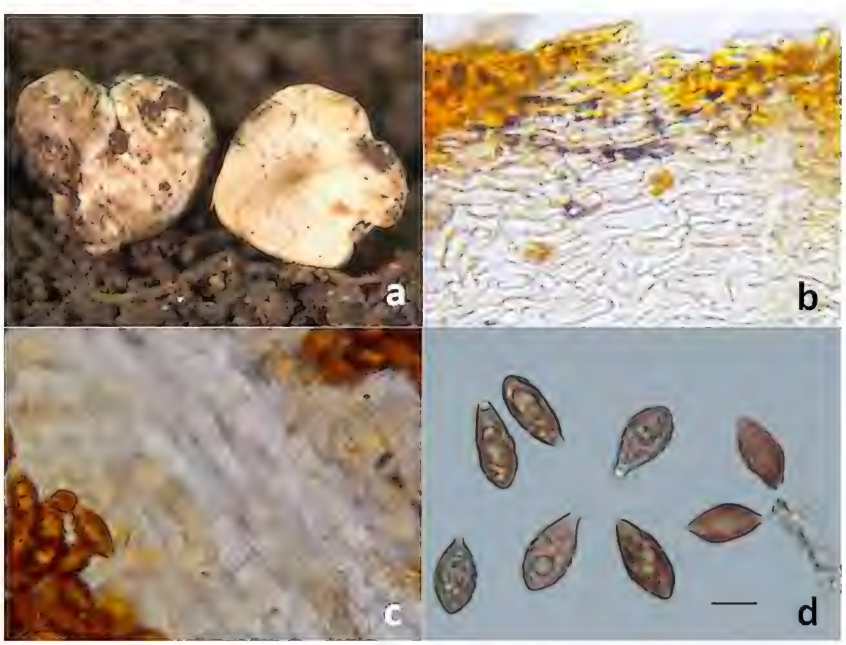

Figure 10. *Hymenogaster rehsteineri* (TARC AT-2177-a):
a. basidiocarp; b. peridium; c. trama; d. basidiospores. Scale bar = 10 µm.

towards the base, the walls ±1 µm thick, 2–4 spored; sterigmata ± 2 µm long. Spores ellipsoid to fusiform, 15–24 × 7–12 µm including ornamentation, mean 19.9 × 8.0 µm, brown, the surface wrinkled, sterigmal appendage prominent, ±1 µm long.

Specimens examined—**TURKEY, Samsun:** Çarşamba, Köklü village, under *Corylus* sp., 12 Nov 2013, Türkoğlu AT-1600; Türkoğlu AT-1602; Türkoğlu AT-1604; Türkoğlu AT-1608; Türkoğlu AT-1609; Türkoğlu AT-1610. **Artvin,** Arhavi, Arılı, in a mixed stand of *Alnus glutinosa, Fagus orientalis, Picea orientalis, Rhododendron ponticum,* and *Salix caprea* 27 Oct 2013 Türkoğlu AT-2177-a. **Yalova,** Güneyköy, under mixed stands of *Fagus orientalis, Quercus petraea,* and *Rhododendron* sp., 21 Nov 2013, Türkoğlu AT-2201. **Tekirdağ,** Saray, Ergene district, under mixed stands of *Carpinus betulus, Pinus nigra,* and *Quercus* sp., 22 Nov 2013, Türkoğlu AT-2210.

Discussion & conclusion

Through this study we have increased the known distribution of ten truffle species as well as provided thorough descriptions of each.

Tuber puberulum is distinguished by its yellow-brown peridium with dermatocystidia and reticulate-alveolate spore ornamentation, contrasting with *Tuber ferrugineum* with a red-brown smooth peridium without regular dermatocystidia and spores ornamented with narrow spines.

Leucophleps aculeatispora has densely ornamented spores with minute spines and is covered with a thin mucilaginous matrix. *Leucophleps aculeatispora* is the only *Leucophleps* species known from Europe, and our material fits the description by Montecchi & Sarasini (2000).

The *Hysterangium calcareum* basidiocarp is covered by mycelium and fine rhizomorphs and produces smaller spores than *H. clathroides.* It appears to be closely associated with *Abies nordmanniana* var. *bornmuelleriana* and *Fagus orientalis* in the Black Sea region.

Sclerogaster compactus has a strongly dextrinoid outer peridial layer composed of tightly interwoven hyphae and large spores in the gleba, whereas *Sclerogaster hysterangioides* has a weakly dextrinoid peridium of parallel to loosely interwoven hyphae and smaller spores.

Melanogaster ambiguus spores are ellipsoid-citriform, papillate, and 13–16 × 7–10 µm, whereas those of *M. macrosporus* are elongate-fusiform, 10–14 × 5–6 µm. *Melanogaster macrosporus* occurs under mixed stands of *Castanea sativa, Fagus orientalis, Picea orientalis,* and *Rhododendron ponticum* in the Black Sea region, whereas *Melanogaster ambiguus* occurs under mixed stands of *Pinus brutia, Quercus cerris,* and *Q. pubescens* in the Mediterranean region.

Our concept of *Hymenogaster rehsteineri* aligns with that of Montecchi & Sarasini (2000). The truffle appears closely associated with *Corylus* spp. and *Fagus* spp. in Europe as well as in Turkey.

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New species and new records of the lichen genus *Fuscopannaria* from China

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Abstract —Four species belonging to the lichen genus *Fuscopannaria* are reported from China: *Fuscopannaria rugosa* sp. nov., *F. cheiroloba* (new to Asia), *F. coralloidea* (new to Asia), and *F. protensa* (new to China). Descriptions and comments for the four species are presented. The type specimen of *F. rugosa* is deposited in HMAS-L.

Key words —*Ascomycota*, *Peltigerales*, *Pannariaceae*, taxonomy

Introduction

Fuscopannaria P.M. Jørg. is a mainly warm-temperate genus belonging to *Pannariaceae*, *Peltigerales*, *Lecanoromycetidae*, *Ascomycota* (Jørgensen 2008, Kirk et al. 2008). It differs from other genera in the family by having a cyanobacterial photobiont (*Nostoc*), a hemiamyloid hymenium, asci with apical amyloid ring-structure, and the presence of thalline margin and absence of lichen substances (terpenoids and fatty acids are sometimes present). It contains about 50 species worldwide (Jørgensen 2003, 2004, 2007, 2008). Fourteen species have been reported from China (Wu & Qian 1999; Jørgensen 2000a, 2004, 2007; Obermayer 2004). *Kroswia* has recently been suggested to be included in *Fuscopannaria* (Magain & Sérusiaux 2014, 2015), but this classification is not followed in the present study (see Liu et al. 2015).

In this paper, *Fuscopannaria rugosa* is described as a new species, *F. cheiroloba* and *F. coralloidea* are reported as new to Asia, and *F. protensa* is reported as new to China.

Materials & methods

Specimens are housed in Herbarium Mycologicum Academiae Sinicae-Lichenes, Beijing, China (HMAS-L), the Herbarium, Kunming Institute of Botany, Chinese

Academy of Sciences, Kunming, China (KUN), and the Herbarium of Shandong Normal University, Jinan, China (SDNU). Morphological, anatomical, and chemical studies were conducted on all specimens following Liu et al. (2015).

Taxonomy

Fuscopannaria rugosa H.J. Liu & J.S. Hu, **sp. nov.** Pl. 1

MycoBank MB 812172

Differs from *Fuscopannaria leucosticta* in the foliose-squamulose thallus, longitudinally wrinkled upper surface, and highly convex discs.

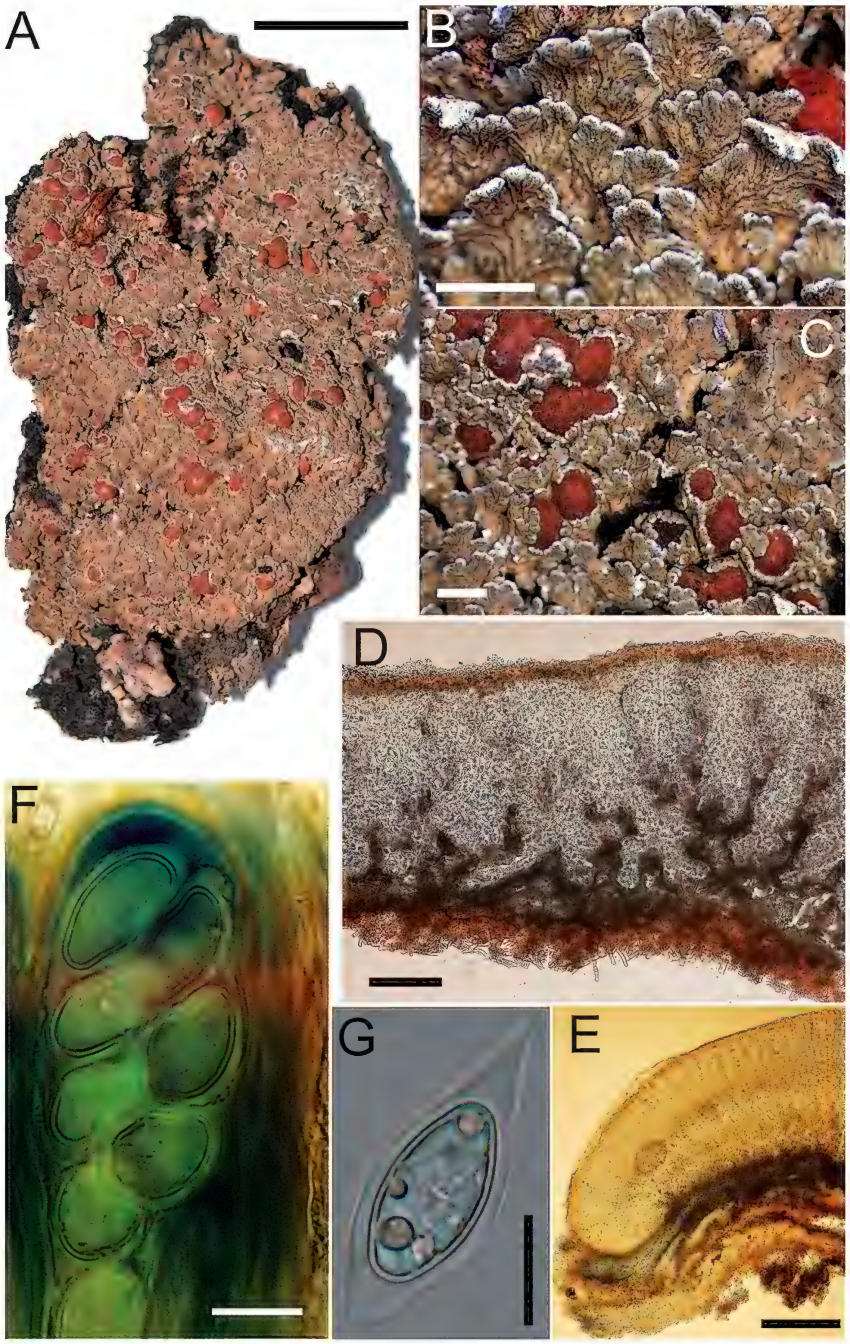
Type: China. Hubei Province, Mt. Shennongjia, 31°30′N 110°16′E, alt. 2540 m, on bark, 30/VII/1984, Jian-Bin Chen 11059 (**Holotype**, HMAS-L 098090).

Etymology: The epithet refers to the wrinkled upper surface.

Thallus foliose-squamulose, forming orbicular rosettes, ≤4–5 cm in diam.; lobes imbricate, fan-shaped, 0.5–1.5 mm wide, branched, flat, free at margin, soon attached to hypothallus towards center, the ends often crenulate and commonly white-felted (ecorticated and exposing the white hyphae); upper surface brown, or sometimes dark olive-green (in particular the "old" lobes), glabrous, shiny, not scabrid, longitudinally wrinkled (wrinkles sometimes indistinct on mature portions), plicate at margin, without isidia, lobules, soredia and pruina; algal layer distinctly dark blue under 10× magnification; lower surface pale near margin, variably becoming dark brown to black towards center, no distinct rhizines and tomenta observed; hypothallus distinct or sometime indistinct, dark brown to black, protruding or not. Apothecia abundant, laminal to submarginal, adnate, circular when young, irregular and 1–2(–2.5) mm in diam. when mature; disc red-brown to paler, shiny, smooth, highly convex when mature; thalline margin glabrous, crenulate and white-felted marginally, distinct, but sometimes covered by disc when mature; proper margin not seen.

Thallus heteromerous, 250–400 μm thick; upper cortex brown, 20–40 μm thick, cells thick-walled; algal layer 200–300 μm, *Nostoc* cells in chains, blue, embedded in a gelatinous layer; medulla thin, 20–30 μm thick, white near lobe margin, blackened towards center and merging into the dark brown to black rhizohyphae; lower cortex absent.

Plate 1. ***Fuscopannaria rugosa*** (holotype, HMAS-L 098090). A. Thallus with apothecia; B. Upper surface, showing fan-shaped lobes with longitudinal wrinkles, crenulate and white-felted margins; C. Apothecia, showing crenulate and marginally white-felted thalline margin; D. Cross-section of thallus; E. Cross-section of apothecium; F. Ascus and ascospores, showing the amyloid ring structure of ascus apex; G. Ascospore, showing distinct, smooth epispore with acuminate ends. Scale bars: A = 1 cm; B, C = 1 mm; D = 100 μm; E = 150 μm; F, G = 10 μm.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Apothecia lecanorine, ≤500 μm thick; thalline exciple 100–150 μm thick at margin, with cortex and algal layer similar to the thallus; proper exciple not seen; epihymenium brown, 10–15 μm thick; hymenium 135–150 μm thick, hemiamyloid (I+ blue, rapidly turning red-brown); subhymenium 160–180 μm thick, without distinct cells; the underneath medulla and algal layer 100–150 μm thick; asci with apical amyloid ring-structure, 8-spored; ascospores monostichous to distichous, simple, ellipsoid, hyaline, true spores 12.5–17.5 × 9–11 μm, 20–30 × 10–12 μm with epispore; epispore acuminate at both ends, smooth, colourless.

Corticolous.

Chemistry: All reactions negative (color test); terpenoids and fatty acids present (TLC).

Additional specimens examined: **China. Hubei Province**, Mt. Shennongjia, 31°30′N 110°16′E, on bark, alt. 2250 m, 30/VII/1984, J.B. Chen 11136 (HMAS-L 098089). **Guangxi Province**, Huaping National Nature Reserve, 25°34′N 109°53′E, on bark, alt. 900–1000 m, 15–17/VIII/1964, J.D. Zhao & L.W. Xu 08710 (HMAS-L 105146), 08857 (HMAS-L 105152), 09038 (HMAS-L 105157).

Remarks: *Fuscopannaria rugosa* is characterized by the foliose-squamulose thallus with longitudinal wrinkles on upper surface, the distinct hypothallus, the thalline and apothecial cortex of thick-walled cells, the thick algal layer (200–300 μm) and simple, hyaline ascospores with a smooth, apically acuminate epispore. The species is corticolous in montane forest from Hubei and Guanxi.

Fuscopannaria rugosa belongs to the *F. leucosticta* group, based on its heteromerous thallus with terpenoids and fatty acids, white-felted lobe margin and apothecial margin, crenulate thalline margin, asci with apical amyloid ring-structure, and smooth epispore. It differs from all other taxa in the group in having distinct, coarse and longitudinal wrinkles on the upper surface. It should be noted that the occasional less than distinct wrinkles and disappearing hypothallus may lead to a confusion with other species in the group. Of these, *F. leucosticta* (Tuck.) P.M. Jørg. can be distinguished by round, broader (>1.5 mm broad) squamules and plane discs; *F. protensa* has a pale brown-ochre, scabrid upper surface; and *F. siamensis* P.M. Jørg. & Wolseley has secondary lobules on the upper surface and smaller spores (18–20 × 9–10 μm; Jørgensen 2000a).

Fuscopannaria cheiroloba (Müll. Arg.) P.M. Jørg., Bryologist 103: 679 (2000). Pl. 2 A–E

Thallus squamulose, usually forming a crust of 3–5 cm in diam.; central squamules dense, granule-like and giving the center of thallus a crustose appearance; marginal squamules spreading, loosely imbricate, free at margin, fan-shaped, ≤3 mm wide, fragile, always incised, not white-felted marginally;

UPPER SURFACE brownish to yellowish-brown, glabrous, smooth, dull to slightly glossy, without isidia, lobules, soredia and pruina; LOWER SURFACE whitish near the margin, darker towards the center, attached to the substrate by hyphae; HYPOTHALLUS commonly indistinct. APOTHECIA abundant, often crowded, laminal to submarginal, sessile, ≤1 mm in diam.; DISC brown to dark brown, smooth, convex; THALLINE MARGIN excluded.

THALLUS heteromerous, thicker in the central squamules, ≤300 µm thick; UPPER CORTEX distinct, 30 µm thick, cells thick-walled; ALGAL LAYER 120–130 µm, *Nostoc* cells in chains, embedded in a gelatinous layer; MEDULLA 30–40 µm thick, with hyphae more compact in upper part, but looser in lower part; LOWER CORTEX absent.

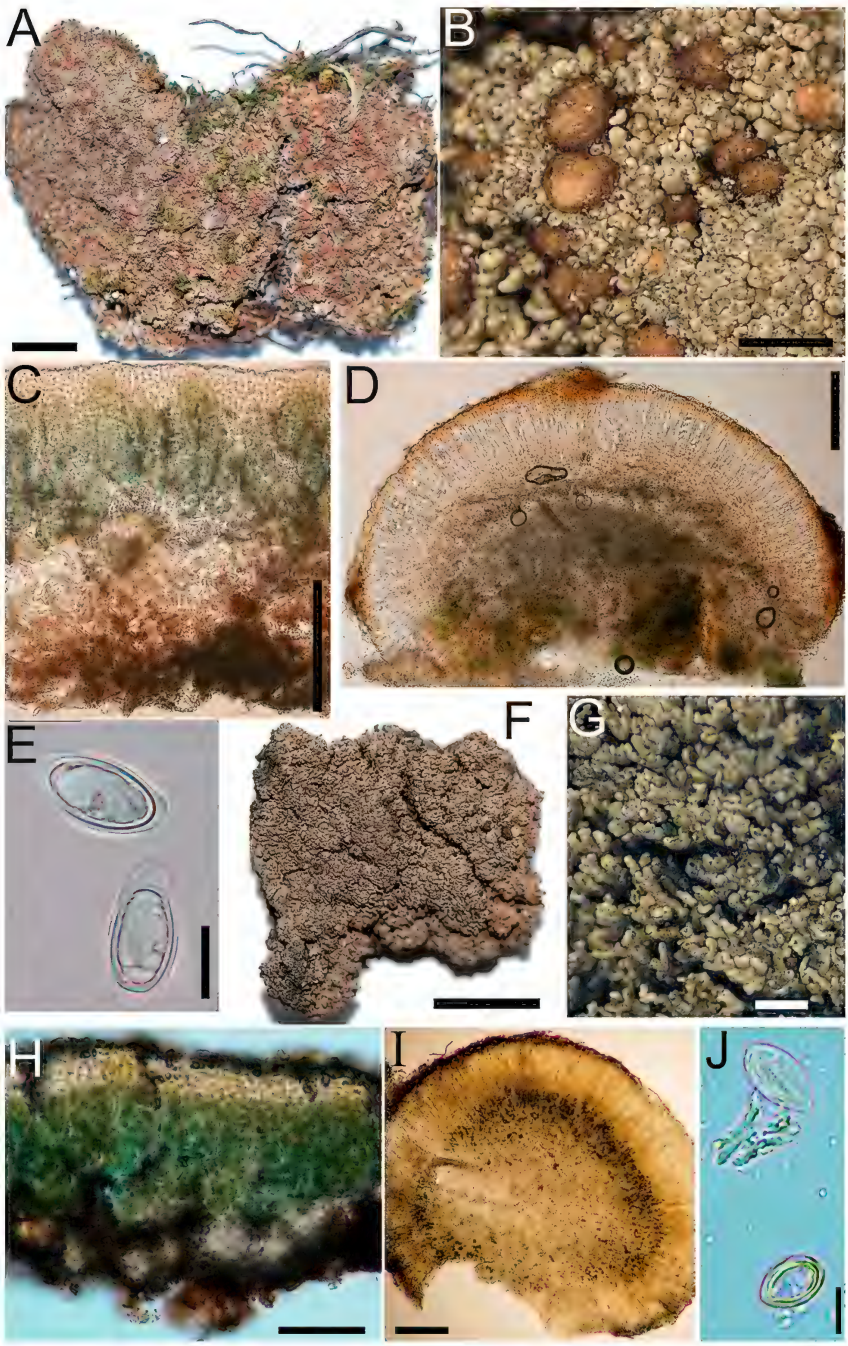
APOTHECIA lecideine, ≤300 µm thick; THALLINE EXCIPLE not seen; PROPER EXCIPLE distinct basally but without regular cellular structure, laterally lacking when mature; EPIHYMENIUM reddish-brown, 10–15 µm thick; HYMENIUM 80–150 µm thick, hemiamyloid; SUBHYMENIUM 150–160 µm; ASCI with apical amyloid ring-structure, 8-spored; ASCOSPORES colourless, simple, ellipsoid or ovoid, 15–20 × 8–10 µm with epispore; EPISPORE smooth, thickened and round at both ends.

Terricolous, saxicolous, corticolous or on mosses.

CHEMISTRY: All reactions negative (color test); no lichen substances detected by TLC.

SPECIMENS EXAMINED: **CHINA. QINGHAI PROVINCE**, Qilian County, Mt. Niuxin, 38°10′N 100°14′E, alt. 2950 m, on moss, 11/VIII/2007, Z.S. Sun 20071442 (SDNU). **SHAANXI PROVINCE**, Mei County, Mt. Taibai, 34°07′N 107°54′E, alt. 2930 m, on soil, 22/VII/1963, Q.M. Ma & Y.C. Zong DI-128 (HMSA-L 073233); alt. 2750 m, on soil, 4/VIII/2005, J.Z. Zhao 813 (HMSA-L 073225); alt. 3180–3500 m, 4–5/VIII/2005, on bark, M.R. Huang 2612 (HMSA-L 075386), on moss, M.R. Huang 3042 (HMSA-L 075411), 3041 (HMSA-L 075412), 3043 (HMSA-L 075413), 2474 (HMSA-L 075414), 2482 (HMSA-L 075415), on soil, 2505 (HMSA-L 075419); alt. 2350 m, on soil, 16/VI/2011, H.Y. Wang 20114996a (SDNU). **SICHUAN PROVINCE**, Xiaojin County, Changpinggou, 31°11′N 102°51′E, alt. 3300 m, on stump, 22/VIII/1996, L.S. Wang 96-17750 (KUN); Kangding County, Liuba Town, 29°28′N 101°32′E, alt. 3100 m, on shrub, 9/IX/1996, L.S. Wang 96-16449 (KUN); Daocheng County, Mt. Haizishan, 29°10′N 100°24′E, alt. 4390 m, on rock, 19/IX/2002, L.S. Wang 02-22259 (KUN); Maerkang County, Dazang Road, 31°54′N 102°12′E, alt. 3200 m, on rock, 7/IX/2007, L.S. Wang 07-29429 (KUN). **XIZANG PROVINCE**, Changdu County, Mt. Machala, 31°12′N 96°36′E, alt. 4650 m, on rock, 20/VIII/2004, L.S. Wang, 04-25557 (KUN).

REMARKS: *Fuscopannaria cheiroloba* is characterized by the granule-like central squamules giving a crustose appearance, the broader and fan-shaped marginal squamules without white-felted margins, a rather thick algal layer (120–130 µm) and the absence of lichen substances. It grows on various substrates in montane forests in China.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J

Fuscopannaria cheiroloba, which morphologically resembles *F. praetermissa* (Nyl.) P.M. Jørg., differs by the presence of fan-shaped marginal squamules and the absence of terpenoids and fatty acids. *Fuscopannaria saltuensis* P.M. Jørg. is also similar to *F. cheiroloba* but has smaller, thinner marginal squamules and smaller ascospores (12–14 × 8–9 µm; Jørgensen 2000a).

Fuscopannaria cheiroloba has been recorded from the USA and Canada (Jørgensen 2000b, Jørgensen et al. 2010). Jørgensen et al. (2010) suggested that "it is endemic to the Pacific Northwest of North America where it apparently is a high elevation species". Our materials, similar to those in USA and Canada in morphology and chemistry (Jørgensen 2000b, Jørgensen et al. 2010), were also collected at high elevations (2350–4650 m). This is the first report from Asia, and its occurrence in China seems to reflect a disjunct distribution between the western North America and China.

Fuscopannaria coralloidea P.M. Jørg., Bryologist 103: 681 (2000). Pl. 2 F–J

Thallus squamulose, forming a rosette of 5–6 cm diam.; squamules numerous, crowded, commonly suberect, deeply and repeatedly branched, with coralloid outgrowths and giving a cushion-like appearance, <0.5 mm wide, plane to slightly convex, somewhat swollen at apex, with entire, glabrous and not white-felted margin; upper surface uniformly brown, smooth, glabrous, without isidia, soredia, lobules and pruina, dull to slightly shiny; lower surface whitish to buff; hypothallus indistinct, blackish to black. Apothecia scarce, scattered, visible on the upper surface, often partly covered by but not hidden in squamules; thalline margin not seen; disc brown to dark brown, 1–1.5 mm diam., strongly convex.

Thallus heteromerous, ≤180 µm thick; upper cortex distinct, pale brown to brown, 25–30 µm thick, cells thick-walled; algal layer 80–110 µm thick, *Nostoc* in chains, embedded in a gelatinous layer; medulla 30–40 µm thick; lower cortex and rhizines absent.

Apothecia lecideine, ≤700 µm thick; thalline exciple not seen; epihymenium dark-brown, 10–15 µm thick; hymenium 130–170 µm thick; asci with apical amyloid ring-structure, 8-spored; ascospores colourless, simple, ellipsoid or ovoid, obtuse at both ends, 15–20 × 8–10 µm with smooth epispore.

On soil-covered rocks.

Plate 2. ***Fuscopannaria cheiroloba*** (HMAS-L 075411). A. Thallus; B. Central squamules and apothecia; C. Cross-section of thallus; D. Cross-section of apothecium; E. ascospores. ***Fuscopannaria coralloidea*** (KUN Wang 09-30569). F. Thallus; G. Coralloid cushion-like squamules; H. Cross-section of thallus; I. Cross-section of apothecium; J. Ellipsoid or ovoid ascospores. Scale bars: A, F = 1 cm; B, G = 1 mm; C, D, I = 150 µm; E, J = 10 µm; H = 50 µm.

Chemistry: All reactions negative (color test); no lichen substances detected by TLC.

Specimens examined: **CHINA. Yunnan Province**, Dongchuan County, Luoxue Town, 26°09′N 102°55′E, on soil-covered rock, alt. 4020 m, 18/VII/2009, L.S. Wang 09-30569 (KUN).

Remarks: *Fuscopannaria coralloidea* is a species of the *F. praetermissa* complex, characterized by a coralloid and cushion-like appearance due to the suberect and branched squamules with abundant outgrowths. *Fuscopannaria abscondita* P.M. Jørg. has a similar coralloid appearance, but is distinguished by having apothecia hidden in squamules rather than visible from above, a higher and more convex cushion-forming thallus (≤1 cm high), and spores with oil droplets (Jørgensen 2000b, Jørgensen & Zhurbenko 2002, Nash et al. 2002).

Fuscopannaria coralloidea is new to Asia and shows a disjunct distribution between western North America and China. It was previously known from the U.S.A. Pacific coast, where it has a lowland distribution and favors moist habitats, especially on mossy soil near rivers or lakes (Jørgensen 2000b, Nash et al. 2002). The Chinese material is similar to that from the US in morphology and ecology (also collected from a moist habitat near Jinsha River), but is found at higher altitudes (alt. 4000 m).

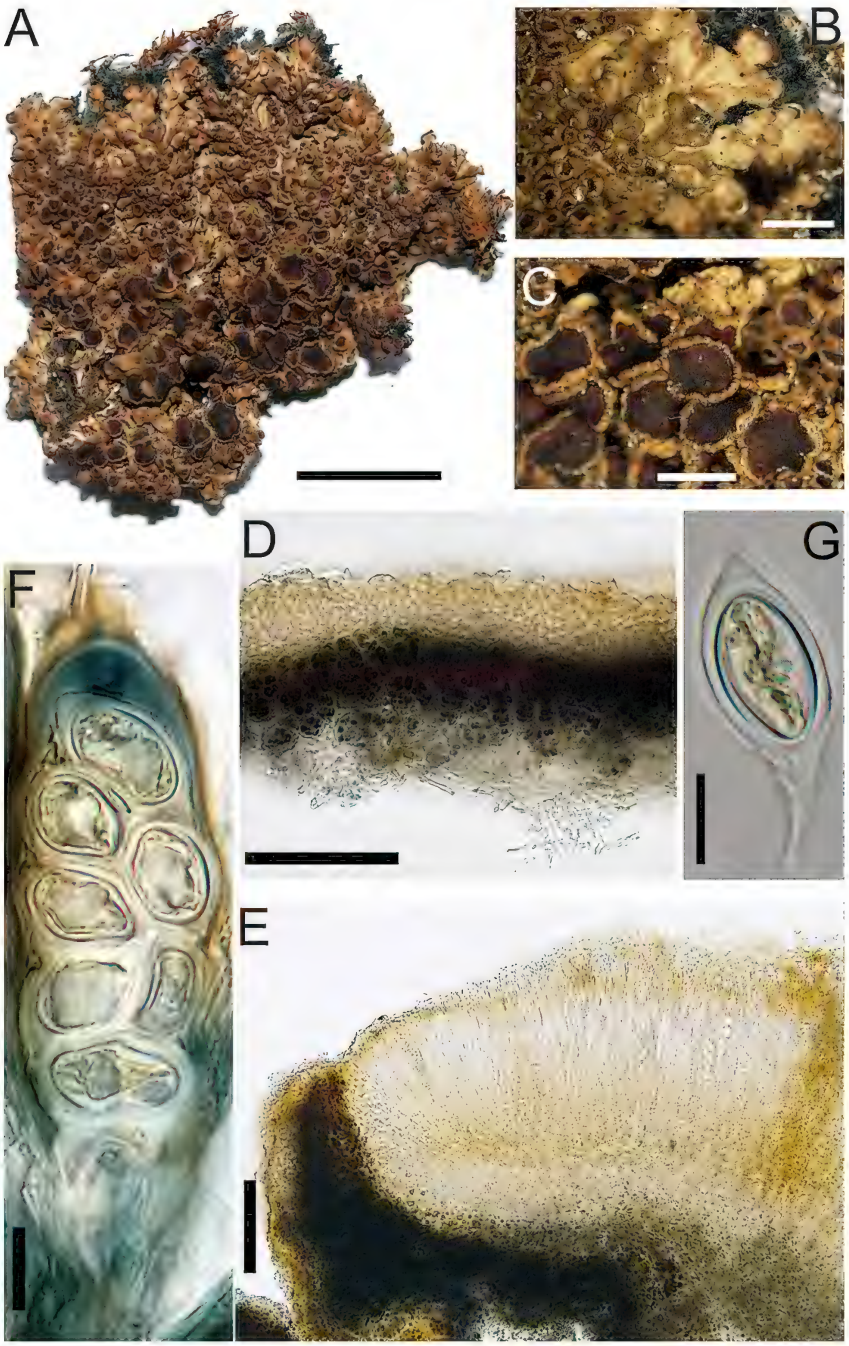
Fuscopannaria protensa (Hue) P.M. Jørg., J. Hattori Bot. Lab. 76: 205 (1994). Pl. 3

Thallus foliose, orbicular, spreading, ≤4 cm in diam.; lobes radiating, about 5 mm wide, slightly branched, entire; upper surface brown-ochre, becoming darker at apex, glabrous, scabrid, without isidia, soredia and lobules, plane, often concave at margin; lower surface with black-blue rhizines at the margin; hypothallus not seen. Apothecia abundant, laminal to submarginal, often crowded at the center of the thallus, ≤4 mm in diam.; disc brown, flat; thalline exciple distinct, concolorous with the thallus, glabrous, smooth, crenulate, with white maculae.

Thallus heteromerous, 120–130 μm thick; upper cortex pale brown, pseudoparenchymatous, 20–40 μm thick; algal layer 20–40 μm thick, *Nostoc* cells in dense clusters with little jelly; medulla 20–30 μm thick; lower cortex absent.

Apothecia lecanorine, ≤400 μm thick; thalline exciple 75–90 μm thick laterally, with cortex and algal layer similar to thallus; proper exciple

Plate 3. ***Fuscopannaria protensa*** (KUN Wang 04-23238). A. Thallus; B. Lobes, showing the scabrous upper surface, concave margin and darker apex; C. Apothecia with crenulate and maculate margin; D. Cross-section of thallus; E. Cross-section of apothecium; F. Ascus and ascospores; G. Ascospores, showing distinct, smooth epispore with one end acuminate. Scale bars: A = 1 cm; B, C = 2 mm; D, E = 100 μm; F, G = 10 μm.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indistinct; EPIHYMENIUM pale brown, 10–20 μm high; HYMENIUM 130–150 μm thick, hemiamyloid; SUBHYMENIUM 70–150 μm thick; ASCI clavate, with apical amyloid ring-structure, 8-spored; ASCOSPORES simple, ellipsoid, hyaline, 20–30 × 10–12 μm with epispore; EPISPORE acuminate at least at one end, smooth, colourless.

Corticolous.

CHEMISTRY: All reactions negative (color test); terpenoids and fatty acids present (TLC).

SPECIMENS EXAMINED: **CHINA. YUNNAN PROVINCE**, Shangri-La County, Gezan Town, Mt. Daxueshan, 28°34′N 99°50′E, on *Rhododendron*, alt. 4060 m, 15/VI/2004, L.S. Wang 04-23238 (KUN); Lijiang County, Mt. Yulongxueshan, Ganheba, 27°05′N 100°16′E, on spruce, alt. 3000 m, 16/V/2005, L.S. Wang 05-24437 (KUN).

REMARKS: *Fuscopannaria protensa* is characterized by the brown-ochre, foliose thallus with radiating lobes and spores with an epispore that is acuminate at least at one end. *Fuscopannaria leucosticta* also has a maculate thalline exciple and acuminate epispore but differs by the brown, squamulose thallus with smooth upper surface and white-felted lobe margins. *Fuscopannaria poeltii* (P.M. Jørg.) P.M. Jørg. differs in its white-felted lobe margins and spores with rounded epispore.

Fuscopannaria protensa was previously known from Korea and Japan (Jørgensen 2000a). It is rare in China and only two collections were found from Yunnan. Our materials closely resemble those from outside China, except for slightly longer spores (18–25 × 10–12 μm including epispore in Korean and Japanese materials; Jørgensen 2000a).

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Four new morel (*Morchella*) species in the elata subclade (*M.* sect. *Distantes*) from Turkey

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Abstract—Four Turkish *Morchella* species identified in published multilocus molecular phylogenetic analyses are described here as new, using detailed macro- and microscopic data: *M. mediterraneensis* (*Mel*-27), *M. fekeensis* (*Mel*-28), *M. magnispora* (*Mel*-29), and *M. conifericola* (*Mel*-32). A distribution map of morels identified to date in Turkey is also provided.

Key words—*Ascomycota*, conservation, edible fungi, *Morchellaceae*, systematics, taxonomy

Introduction

True morels (*Morchella*), among the most highly prized edible macrofungi, are classified in the *Morchellaceae* (*Pezizales, Ascomycota*). This monophyletic family also includes *Disciotis*, *Kalapuya*, *Fischerula*, *Imaia*, *Leucangium*, and *Verpa* (O'Donnell et al. 1997, Trappe et al. 2010). Several multilocus DNA sequence-based analyses of *Morchella* that employed phylogenetic species recognition based on genealogical concordance (GCPSR sensu Taylor et al. 2000) have revealed that most species exhibit continental endemism and provincialism in the northern hemisphere (Du et al. 2012a, b; O'Donnell

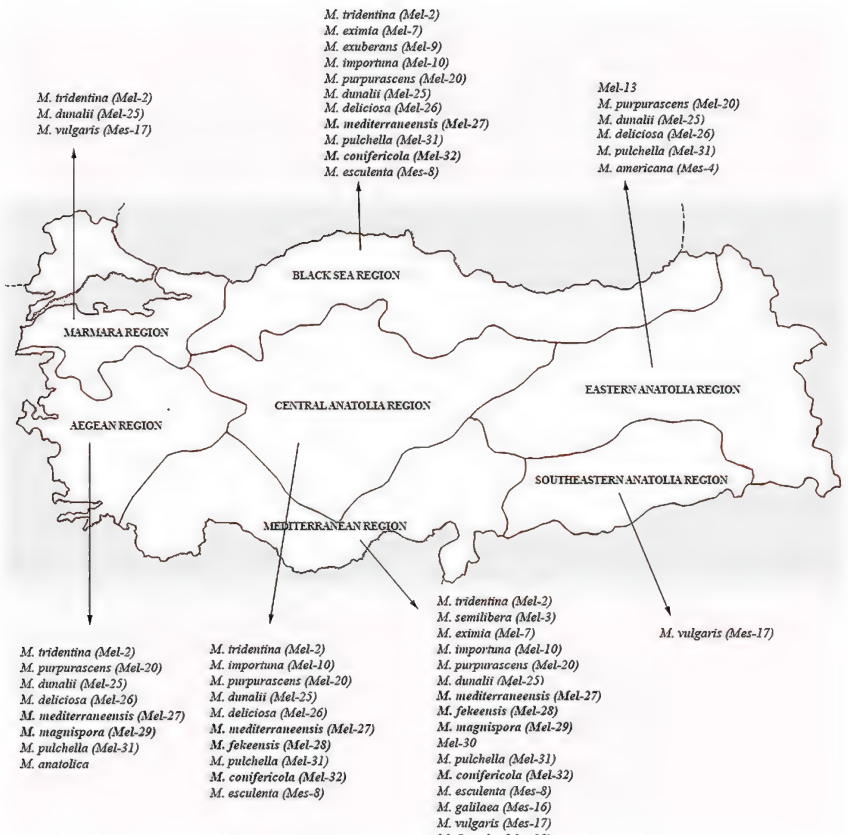

Fig. 1. Distribution of *Morchella* species in the seven geographic regions of Turkey

et al. 2011; Richard et al. 2015; Taşkın et al. 2010, 2012). These studies have also helped evaluate recent systematic studies based on morphological species recognition (Clowez 2012, Clowez et al. 2014) and provided a robust framework for taxonomic revision (Kuo et al. 2012, Richard et al. 2015).

Twenty-one of the 65 genealogically exclusive *Morchella* species discovered to date have been reported from Turkey (Işıloğlu et al. 2010; Taşkın et al. 2010, 2012). GCPSR-based studies of 491 Turkish collections, which included *M. anatolica* Işıloğlu et al. from the southwestern Anatolia region, recognized six undescribed species within the elata subclade (*M.* sect. *Distantes*). The undescribed species within this clade were assigned informal code names consisting of *Mel* followed by a unique Arabic number (Fig. 1). Here, four of these phylogenetically distinct species—previously reported as *Mel*-27, *Mel*-28,

Mel-29, and *Mel*-32 (Taşkın et al. 2010, 2012)—are formally described as new species.

Materials & methods

Specimens examined here were collected in different regions of Turkey from 2007 through 2010 (Fig. 1) and then deposited in the Ankara University Herbarium, Ankara, Turkey (ANK). The Munsell Book of Color (Munsell 1976) was used as the reference for all colors reported. Microscopic characters were measured with a Leica DM 3000 compound microscope at 400× magnification of mounts using Melzer's reagent, 2% KOH, or water. Light microscopic images were obtained using bright field optics. At least 20 mature ascospores were measured from each specimen, with Q values (length divided by width) determined from water mounts from dried specimens. The new term "acroparaphyses" (proposed by Loizides et al. 2016) is used for the sterile elements of the ridges.

Scanning electron micrographs were obtained following Elliott et al. (2014): an approximately 3×3 mm^2 piece of hymenium was excised from an air-dried ascocarp and rehydrated in 500 µL of sterile distilled water in a 1.5 mL Eppendorf tube. The hydrated hymenium was macerated gently with a pipette tip to dislodge intact ascospores and then vortexed briefly. After precipitation of the large hyemnial fragments, the ascospore suspension was transferred to a new 1.5 mL Eppendorf tube and washed with two exchanges of distilled water. An aliquot of the suspension was then pipetted onto a microscope cover slip mounted on a SEM stub where it was airdried. Dried samples were coated with gold-palladium prior to examination with a JEOL 6400V scanning electron microscope.

Pure cultures of three of the four holotypes described here were obtained following a published protocol (O'Donnell et al. 2011) and deposited in the ARS Culture Collection (http://nrrl.ncaur.usda.gov/), National Center for Agricultural Utilization Research, Peoria IL, USA (NRRL), where they are stored in liquid nitrogen vapor at –75°C in a cryogen composed of 1% DMSO and 10% skim milk.

Taxonomy

Morchella mediterraneensis Taşkın, Büyükalaca & H.H. Doğan, **sp. nov.** Figs 2–4

MycoBank MB 813585

Differs from *Morchella snyderi*, its reciprocally monophyletic sister species in the western United States, by distinctly smaller spores and young specimens with greenbluish tinges and dark ridges.

Type—Turkey, Kayseri, Yahyalı, 37°48'08"N 35°18'03"E, 1618 m, under *Abies cilicica* (Antoine & Kotschy) Carrière, 8 May 2010, coll. Taşkın 478, (**Holotype**, ANK Taşkın 98; ex-type culture, NRRL 53842).

Etymology—from the Mediterranean biogeographical area, to reflect the widespread distribution of this species in southern Turkey.

Ascomata medium-sized, with conical pileus attached to the stipe with a deep narrow sulcus, edges dark violet to black and pits gray to olive gray with

bluish tinges turning light honey brown to dark golden brown with age. Spores measuring 20–24 × 11.2–13.8 µm, faintly wrinkled when viewed by scanning electron microscopy. Paraphyses 2–4-septate, terminal cell cylindrical to subclavate, 12–15 µm diam. Acroparaphyses lanceolate to clavate, 10–23 µm diam, thick-walled.

Macromorphological characters — Ascomata 25–60 mm high, stipe often constricted at the base. Pileus hollow, at first bluntly conical to broadly ovoid-elliptical or cylindrical, then conical to sharply conical at the tip, 20–50 mm at broadest point, pitted and ridged, attached to the stipe by a distinct narrow (but often deep) sulcus (sinus); ridges 1–3 mm broad, primary ridges 15–20 per ascoma, longitudinal from base to tip of ascoma, a few shorter, connected by secondary cross-ridges, 5–10 horizontally oriented; edges minutely granular, uniformly dark violet-black (5PB2/6) at first, black (2.5B 1/2) at maturity. Pits irregular, generally with 3–5 sides, surface granulose, light gray to light olive gray with bluish tint (N5) at first, light honey brown (7.5YR 7/10) to dark golden brown (7.5YR 5/8) at maturity. Stipe cylindrical to laterally compressed, usually widening at base with coarse ridges or folds, hollow, 20–50 mm high, 5–30 mm wide, increasingly covered with minute whitish granules with maturity, entirely cream-white (N9) when young, light honey brown (7.5YR 7/10) at maturity. Sterile inner cavity white to light honey yellow at first, turning light honey brown (7.5YR 7/10) and finely granular as ascocarps mature.

Micromorphological characters — Ascospores (18–)20–24(–25) × (11.2–)12–13.8(–14.6) µm, mean Q = 1.77; elliptical to oblong, hyaline, surface distinctly wrinkled under SEM; spore wall ± 0.7 µm thick. Asci cylindrical, straight, (270–)290–320(–320) × (17–)19–22(–25) µm, 8-spored, hyaline, thin-walled without crozier. Paraphyses shorter than asci, terminal cell cylindrical, subclavate, (200–)220 × 270(–290) × 12–15 µm; 2–4-septate. Acroparaphyses straight; clavate, lanceolate to subclavate, very rarely subcapitate, capitate elements absent; 70–170 × 10–23 µm, 2–5-septate, terminal cell 70–110 µm long, wall thickness 1.3–1.5 µm, usually filled with refractory material, wall deposit light yellowish orange.

Ecology and distribution — *Morchella mediterraneensis* was collected under *Pinus brutia*, *P. nigra*, *Cedrus libani*, *Juniperus excelsa*, *J. foetidissima*, *Abies cilicica*, and *Quercus coccifera* in Adana, Mersin, and Kahramanmaraş provinces in the Mediterranean region, Konya and Kayseri provinces in the Central Anatolia region, Denizli province in the Aegean region, and Kastamonu province in the Black Sea region (Taşkın et al. 2010, 2012).

Additional collections examined — **TURKEY: Mersin**, Erdemli, 36°42′07″N 33°59′56″E, 1335 m elev., under *P. brutia*, *A. cilicica*, *J. excelsa*, *J. foetidissima*, 16 April

Figs 2–4. *Morchella mediterraneensis* (Taşkın 478, holotype). 2. Ascocarp. 3. Clavate acroparaphyses on ridge. 4. SEM of ascospore with irregular striae. Scale bars: 2 = 1 cm; 3 = 20 µm; 4 = 5 µm.

2007, coll. Taşkın 25 (ANK Taşkın 47); **Kahramanmaraş**, Göksun, 38°08′00″N 36°35′04″E, 1685 m elev., under *P. brutia*, *P. nigra*, *J. excelsa*, *J. foetidissima*, *A. cilicica*, 5 May 2008, coll. Taşkın 207 (ANK Taşkın 37, ANK Taşkın 38); **Kastamonu**, Ağlı, 19 May 2008, coll. Taşkın 107, 118 (ANK Taşkın 53, ANK Taşkın 55); **Adana**, Feke, 37°57′18″N 35°48′12″E, 1632 m elev., under *P. nigra*, *C. libani*, *A. cilicica*, *J. excelsa*, *J. foetidissima*, 14 April 2010, coll. Taşkın 520 (ANK Taşkın 100); **Konya**, Beyşehir,

37°37′36″N 31°20′13″E, 1665 m elev., under *P. nigra*, *C. libani*, *A. cilicica*, 5 May 2010, coll. Taşkın 448 (ANK Taşkın 97);. **Kayseri**, Yahyalı, 37°48′08″N 35°18′03″E, 1618 m elev., under *A. cilicica*, 8 May 2010, coll. Taşkın 481 (Çukurova Univ.). **SPAIN**: **Malaga**, Parauya, Parco Natural de la Sierre de las Nieves, 1100 m elev., under *Abies pinsapo*, 8 May 2013, M. Becerra Parra (LIP, Clowez PhC252).

Comments—*Morchella mediterraneensis* was previously reported as *Mel*-27 (Du et al. 2012a, b; Taşkın et al. 2010, 2012); it was the second most common morel collected in Turkey, representing 83 of the 491 collections. Of these, 67/83 were from the Mediterranean region (Taşkın et al. 2012). Collections from Greece (Loizides et al. 2016) and Spain (M. Becerra Parra, ex herb. P. Clowez) confirm that its distribution extends beyond the Turkish borders and that it might be even more widespread in the Mediterranean basin. This species was strongly supported as the reciprocally monophyletic sister clade to *M. snyderi* (*Mel*-12), a species that is so far considered endemic to western North America (Kuo et al. 2012, Du et al. 2012a, O'Donnell et al. 2011, Taşkın et al. 2012). Maximum likelihood-based analyses suggest that the geographic range of the most recent common ancestor of *M. synderi* expanded via dispersal across the Beringian land bridge into western North America in the late Miocene to Pliocene (Du et al. 2012a). ITS rDNA sequence data cannot be used to distinguish *M. mediterraneensis* (*Mel*-27) from *M. pulchella* (*Mel*-31) from Turkey and France, *M. septentrionalis* (*Mel*-24) from eastern North America, and *Morchella* sp. (*Mel*-23) from northern Europe (Du et al. 2012b). Therefore, for a definitive identification, we recommend using portions of the four genes that resolved this species as genealogically exclusive (Taşkın et al. 2012). Morphologically, *M. mediterraneensis* is very similar to *M. dunalii* (*Mel*-25), which also displays dark edges and pale pits, but differs microscopically by strongly inflated to lobate acroparaphyses (Loizides et al. 2016). *Morchella kakiicolor*, known only from Spain and insufficiently documented regarding macromorphology, shows paler edges and a less conical shape (Loizides et al. 2015). *Morchella deliciosa* (*Mel*-26) and *M. purpurascens* (*Mel*-20) have pinkish to dark purplish tinges and a narrowly conical to cylindrical pileus that is at least twice larger than broad.

Morchella fekeensis H.H. Doğan, Taşkın & Büyükalaca, **sp. nov.** Figs 5–7

MycoBank MB 813587

Differs from *Morchella brunnea* and *M. snyderi*, its reciprocally monophyletic sister species in the western United States, by its genealogical exclusivity in a multigene phylogenetic analysis and apparent endemism in Turkey.

Type—Turkey, Yozgat, Akdağ madeni, 39°35′05″N 35°56′14″E, 1449 m, under *Pinus sylvestris* L., 29 April 2010, coll. Taşkın 401 (**Holotype**, ANK Taşkın 101; ex-type culture, NRRL 53820).

Figs 5–7. *Morchella fekeensis* (Taşkın 401, holotype). 5. Ascocarp. 6. Clavate acroparaphyses on ridge. 7. SEM of ascospore with longitudinal and irregular striae. Scale bars: 5 = 1 cm; 6 = 20 µm; 7 = 5 µm.

Etymology—referring to Turkey's Feke (Adana) province where some of the specimens were collected.

Ascomata small-sized, 10–30 mm high. Pileus cylindrical then bluntly conical or ovoid, with irregular, vertically arranged pits yellow-orange to yellow-brown with age, with granular surface. Stipe whitish at first, covered with whitish to

yellow orange granules with age. Ascospores 22.5–25.5 × 12.5–15.5 µm, wrinkled when viewed by scanning electron microscopy. Paraphyses 2–5-septate, terminal cell cylindrical, subclavate to subcapitate, 12–14 µm diam. Acroparaphyses lanceolate to clavate, 9.9–18.6 µm diam.

Macromorphological characters—Ascomata 10–30 mm high, stipe often constricted at base. Pileus hollow, ovoid-elliptical or cylindrical at first, then bluntly conical or ovoid at apex, 5–30 mm diam at widest point, pitted and ridged, attached to stipe with a distinct incurved sulcus; primary ridges 10–16 per ascoma, longitudinal from base to tip, with a few shorter vertical secondary ridges, and 5–8 horizontal cross-ridges; edges 1–2 mm broad, finely granular, light gray black (5PB 2/6) at first, dark black (2.5B 1/2) at maturity, transecting ridges bright yellowish brown (10YR 7/6). Pits irregular, generally with 2–5 sides, surface granulose, deeply sinuous, yellow orange (10YR 8/6) to bright yellowish brown (10YR 7/6) at first, then turning yellowish brown (10YR 5/8) to dark golden brown (7.5YR 5/8) at maturity. Stipe cylindrical to laterally compressed, usually tapered at base with thin ridges or folds, hollow, 5–30 mm high, 5–10 mm wide, increasingly covered with rough whitish to yellow orange granules (10YR 8/8) as ascocarps mature, completely cream-white when young, light honey brown (7.5YR 7/10) at maturity. Sterile inner cavity white to light honey yellow at first, turning light honey brown (7.5YR 7/10) at maturity.

Micromorphological characters—Ascospores 22.5–25.5(–27) × 12.5–15.5 µm, mean Q = 1.76; elliptical to oblong, hyaline, wall with straight to sinuous ridges often connected with low, crowded, transverse ridges under SEM, spore wall ± 0.7 µm thick. Asci crowded, cylindrical, straight, 240–300(–340) × 20–24 µm, 8-spored, hyaline, thin-walled. Paraphyses shorter than asci, terminal cell cylindrical, subclavate to subcapitate; 175–260 × 12–14 µm; 2–5-septate. Acroparaphyses straight; clavate, lanceolate to subclavate, very rarely subcapitate, capitate elements absent; 119–163 × 9.9–18.6 µm, 2–4-septate, terminal cell 50–110 µm long, usually filled with refractory material.

Ecology and distribution — *Morchella fekeensis* was collected under conifers (*Pinus brutia*, *P. nigra*, *P. sylvestris*, *Cedrus libani*, *Abies cilicica*, *Juniperus* sp.) in Adana and Kahramanmaraş provinces in the Mediterranean region, and Yozgat and Sivas provinces in the Central Anatolia region (Taşkın et al. 2010, 2012).

Additional collections examined — **TURKEY**: **Adana**, Feke, 37°51′56″N 35°48′05″E, 1325 m elev., under *P. brutia*, *P. nigra*, *C. libani*, *A. cilicica*, 20 April 2007, coll. Taşkın 50 (ANK Taşkın 03); **Kahramanmaraş**, Göksun, 38°08′15″N 36°34′20″E, 1630 m elev., under *C. libani*, *A. cilicica*, *Juniperus* sp., 22 May 2008, coll. Taşkın 201 (ANK Taşkın 45); **Sivas**, Koyulhisar, 40°21′05″N 37°54′56″E, 1963 m elev., under

P. brutia, *P. nigra*, *A. cilicica*, 27 May 2008, coll. Taşkın 251 (ANK Taşkın 62); **Yozgat**, Akdağ madeni, 39°35′05″N 35°56′14″E, 1449 m elev., under *P. sylvestris*, 29 April 2010, coll. Taşkın 507 (ANK Taşkın 102); Akdağ madeni, 39°34′47″N 35°56′40″E, 1593 m elev., under *P. sylvestris*, 29 April 2010, coll. Taşkın 510 (ANK Taşkın 103).

Comments — *Morchella fekeensis* was reported previously as *Mel*-28 (Du et al. 2012a, b; Taşkın et al. 2010, 2012). GCPSR-based studies strongly support the reciprocal monophyly of *M. fekeensis* and the western Northern American endemic, *M. brunnea* (*Mel*-22; Taşkın et al. 2010, 2012; O'Donnell et al. 2011), from which it differs mainly by smaller, less conical ascomata, distinctly smaller spores, and acroparaphyses that are not distinctly capitate. With only nine collections (six from Central Anatolia, three from the Mediterranean region), *M. fekeensis* appears to be relatively rare in Turkey. Maximum likelihood-based analyses suggest that the geographic range of the most recent common ancestor of *M. brunnea* expanded via a dispersal across the Beringian land bridge into western North America in the late Pliocene to Pleistocene (Du et al. 2012a). Preliminary data suggest that ITS rDNA sequences might be useful in distinguishing *M. fekeensis* from closely related elata subclade species (Du et al. 2012b). However, for a definitive identification, we recommend sequencing portions of the four genes that resolved this lineage as genealogically exclusive.

Morchella fekensis is one of the smallest species in *M.* sect. *Distantes*, characterized by a distinctly sulcate stipe that stains yellowish with age and a yellow to yellow-brown pileus with edges staining black with age. It belongs to the "*Mel*-17–34 complex," close to the European *M. pulchella* (*Mel*-31), the North American *M. septentrionalis* (*Mel*-24), and several still unnamed Eurasian species represented by single collections (Richard et al. 2015). Also described as small, *M. pulchella* is distinguished by its greenish-gray coloration and a non-sulcate stipe.

Morchella magnispora Büyükalaca, H.H. Doğan & Taşkın, **sp. nov.** Figs 8–10

MycoBank MB 813588

Differs from *Morchella brunnea* and *M. fekeensis*, its reciprocally monophyletic sister species, by its stipe turning honey-brown with age, its narrow sulcus, its genealogical exclusivity in a multigene phylogenetic analysis, and its apparent endemism in Turkey.

Type—Turkey, Uşak, Bahadır, 38°50′49″N 29°45′19″E, 1208 m, under *Pinus nigra*, 5 April 2010, coll. Taşkın 470 (**Holotype**, ANK Taşkın 104; ex-type culture, NRRL 53796).

Etymology—from Latin: *magnus* = large, *spora* = spore; referring to the large ascospores produced by this species.

Ascomata small- to medium-sized, with ovoid to bluntly conical pileus at first, sharply conical with age, attached to the stipe by a narrow sulcus; edges early dark violet then black; pits irregular and mostly tetragonal, light smoky brown when young, dark brown when mature; stipe initially white, in age light

honey brown. Ascospores 24–31 × 13–21 µm, faintly wrinkled when viewed by scanning electron microscopy. Paraphyses 1–3-septate, terminal cell cylindrical to subcapitate, 11–17 µm diam. Acroparaphyses lanceolate to clavate, rarely subcapitate, 13.6–30.5 µm diam.

Macromorphological characters—Ascomata 20–50 mm high, margin constricted where attached to stipe. Pileus hollow, slightly ovoid-elliptical or cylindrical to bluntly conical at first, then conical to sharply conical at the tip, 15–40 mm diam. at widest point, pitted and ridged; primary ridges longitudinal, 12–16 per ascoma, all from base of ascomata to tip, secondary ridges only horizontal, 6–10 per primary pit; edges finely granular, dark violet-black (5PB2/6) at first, dark black (2.5B 1/2) at maturity. Pits deeply irregular and tetragonal, surface granulose, light smoky brown (7.5YR 5/6) to brown (7.5YR 4/4) at first, then dark brown (7.5YR 3/4) at maturity. Stipe cylindrical to laterally compressed, usually widening at base with coarse ridges or folds, hollow, 30–70 mm long, 5–30 mm wide, increasingly covered with coarsely whitish granules as ascocarps mature, completely cream-white (N9) when young, light honey brown (7.5YR 7/10) at maturity. Sterile inner cavity white to light honey yellow at first, then light honey brown (7.5YR 7/10).

Micromorphological characters—Ascospores 24–31 × 13–21 µm, mean Q = 1.65; elliptical to oblong, hyaline, content homogeneous, polar oil drops absent, longitudinally striate when viewed via SEM; spore wall ± 0.5 µm thick. Asci crowded, cylindrical, straight, 230–350 × 15–25 µm, 8-spored, hyaline, thin-walled. Paraphyses shorter than asci, terminal cell cylindrical, subclavate, subcapitate, 190–250 × 11–17 µm; 1–3-septate. Acroparaphyses straight; clavate, lanceolate to subclavate, very rarely subcapitate, capitate elements absent; 143–192 × 13.6–30.5 µm, 2–4-septate, terminal cell 98–130 µm long, usually filled with refractory material.

Ecology and distribution — *Morchella magnispora* was collected under *Pinus brutia*, *P. nigra*, *Cedrus libani*, *Abies cilicica*, *Quercus coccifera*, and *Juniperus* sp. in Aydın and Uşak provinces in the Aegean region, and Adana, Kahramanmaraş, Mersin, and Muğla provinces in the Mediterranean region (Taşkın et al. 2010, 2012).

Additional collections examined — **TURKEY**: **Mersin**, Gülnar, 36°18′20″N 33°25′57″E, 780 m elev., under *P. brutia*, 28 March 2007, coll. Taşkın 82 (ANK Taşkın 05); **Adana**, Feke, 37°51′56″N 35°48′05″E, 1325 m elev., under *C. libani*, *A. cilicica*, *Juniperus* sp., 20 April 2007, coll. Taşkın 45 (ANK Taşkın 23); **Muğla**, Fethiye, 36°50′38″N 29°07′14″E, 1048 m elev., under *P. brutia*, *Q. coccifera*, 15 April 2008, coll. Taşkın 189 (Çukurova Univ.); **Aydın**, Bozdoğan, 37°37′13″N 28°19′15″E, 819 m elev., under *P. brutia*, *P. nigra*, 17 April 2008, coll. Taşkın 155 (ANK Taşkın 04); **Uşak**, Bahadır, 38°50′49″N 29°45′18″E, 1216 m elev., under *P. nigra*, 5 April 2010, coll. Taşkın 471 (ANK Taşkın 105).

Figs 8–10. *Morchella magnispora* (Taşkın 470, holotype). 8. Ascocarp. 9. Clavate acroparaphyses on ridge. 10. SEM of ascospore with delicate striae. Scale bars: 8 = 1 cm; 9 = 20 µm; 10 = 5 µm.

Comments — *Morchella magnispora* was previously reported as *Mel*-29 (Du et al. 2012a, b; Taşkın et al. 2010, 2012). Only nine collections of this rare species were made, including six from the Aegean and three from Mediterranean region (Taşkın et al. 2012). *M. magnispora* was resolved as a reciprocally monophyletic sister to *M. fekeensis* + *M. brunnea*. Presumably the allopatric speciation of

the latter sister taxa was associated with the geographic range expansion of the most recent common ancestor of *M. brunnea* across the Beringian land bridge into western North America in the late Pliocene to Pleistocene (Du et al. 2012a). Preliminary data suggest that ITS rDNA sequences may be useful in distinguishing *M. magnispora* from closely related elata subclade species (Du et al. 2012b). *Morchella magnispora* is an distinctive species in the mainly Eurasian "*Mel*-17–34 complex" (Richard et al. 2015) in that the stipe turns honey-brown with age and the sulcus is narrow; it shares similarities with the North American species *M. brunnea* (*Mel*-22), including the brown colors with dark edges from young stages and large spores (which are longer than in other European species of *M.* sect. *Distantes* described, e.g., by Clowez 2012, but they fall within the broad spore range of *M. brunnea* as described by Kuo et al. 2012: "22–36(–40) × 14–20(–25) µm").

Morchella conifericola Taşkın, Büyükalaca & H.H. Doğan, **sp. nov.** Figs 11–13

MycoBank MB 813590

Differs from *Morchella septentrionalis* and *M. pulchella,* its reciprocally monophyletic sister species, by its genealogical exclusivity in a multigene phylogenetic analysis and its apparent endemism in Turkey.

Type—Turkey, Kayseri, Yahyalı, 37°48′08″N 35°18′03″E, 1618 m, under *Abies cilicica*, 8 May 2010, coll. Taşkın 477 (**Holotype**, ANK Taşkın 110).

Etymology — from Latin, *coniferi*: conifers (*Pinales*), and *cola* = to dwell or inhabit; referring to the distribution under conifers.

Ascomata small- to medium-sized, with elliptical to conical pileus becoming sharply conical with age, attached to the stipe with a narrow, incurved sulcus; edges dull orange at first then brownish black; pits irregularly polygonal, light yellow orange to bright brown at maturity; stipe not distinctly sulcate, white then light honey-brown at maturity, covered with coarse whitish granules. Ascospores (21–)22–25 × (10–)12–14 µm, distinctly striate when viewed by scanning electron microscopy. Paraphyses 3–5-septate, terminal cell cylindrical to subclavate, 10–15 µm diam. Acroparaphyses lanceolate to clavate, rarely subcapitate, 10–31.5 µm diam.

Macromorphological characters — Ascomata 30–60 mm high, margin constricted where attached to stipe. Pileus hollow, elliptical-cylindrical to conical at first, then conical to sharply conical at the tip, 15–25 mm diam. at widest point, pitted and ridged. Primary ridges 12–16 per ascoma, longitudinal from base of ascomata to tip, connected by 5–10 secondary cross-ridges; edges finely granular, dull orange (5YR 7/4) at first, brownish black (5YR 2/1) at maturity. Pits deeply irregular and tetragonal, surface granulose, light yellow

Figs 11–13. *Morchella conifericola* (Taşkın 477, holotype). 11. Ascocarp. 12. Clavate acroparaphyses on ridge. 13. SEM of ascospore with prominent longitudinal striae interconnected by delicate horizontal striae. Scale bars: 11 = 1 cm; 12 = 20 µm; 13 = 5 µm.

orange (7.5YR 8/3) to dull orange (7.5YR 7/3) at first, then bright brown (7.5YR 5/6) at maturity. Stipe cylindrical, slightly widening at base, coarse ridges or folds absent, hollow, 30–50 mm long, 5–20 mm wide, increasingly covered with coarse whitish granules, completely cream-white (N9) when

young, light honey brown (7.5YR 7/10) at maturity. Sterile inner cavity white to light honey yellow at first, then light honey brown (7.5YR 7/10) and finely granulose at maturity.

Micromorphological characters — Ascospores (21–)22–25 × (10–)12–14 µm, mean Q = 1.84; elliptical to oblong, hyaline, content homogeneous, polar oil drops absent, surface with longitudinal and anastomosing striations under SEM; spore wall ± 0.7 µm thick. Asci crowded, cylindrical, straight, (290–)300–370(–390) × (18–)20–23 µm, 8-spored, hyaline, thin-walled. Paraphyses shorter than asci, terminal cell cylindrical, subclavate, (190–)230–275(–300) × 10–15 µm; 3–5-septate. Acroparaphyses straight; clavate, lanceolate to subclavate, very rarely subcapitate, capitate elements absent; 85–185 × 10–31.5 µm, 3-septate, terminal cell 41–98 µm long, usually filled with refractory material.

Ecology and distribution — *Morchella conifericola* was collected under *Pinus nigra*, *Cedrus libani*, and *Abies cilicica* in Kastamonu province (Black Sea region), Kayseri province (Central Anatolia region) (Taşkın et al. 2010, 2012) and Kahramanmaraş province (Mediterranean region) (unpublished).

Additional collections examined — **TURKEY: Kayseri**, Yahyalı, 37°48′08″N 35°18′03″E, 1618 m elev., under *A. cilicica*, 8 May 2010, coll. Taşkın 479 (ANK Taşkın 111).

Comments—*Morchella conifericola* was previously reported as *Mel*-32 (Du et al. 2012a, b; Taşkın et al. 2012). This rare species was represented by a single collection from the Black Sea and two collections from the Central Anatolia regions. GCPSR-based studies strongly support *M. conifericola* as sister to *Mel*-23 + *M. septentrionalis* + *M. pulchella* (Taşkın et al. 2012). *Morchella conifericola* was nested phylogenetically within a poorly resolved clade with *M. pulchella* (*Mel*-31) from Turkey, China, and France, *M. septentrionalis* (*Mel*-24) from eastern North America, and *Morchella* sp. (*Mel*-23) from northern Europe. *Morchella septentrionalis* is theorized to have evolved from a Eurasian ancestor whose geographic range expanded into North America via the Beringian land bridge in the late Pliocene to Pleistocene (Du et al. 2012a). Preliminary data suggest that ITS rDNA sequences might be useful in distinguishing *M. conifericola* from closely related elata subclade species (Du et al. 2012b). However, for a definitive identification, we recommend using portions of the four marker loci that were used to resolve this lineage as genealogically exclusive.

Morchella conifericola shows morphological affinities with *M. magnispora* (*Mel*-29), from which it differs mainly by its stipe that lacks wrinkles (or possesses indistinct ones), and smaller spores that are distinctly striate under SEM. See also remarks under *M. magnispora*.

Acknowledgments

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MYCOTAXON

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Regional annotated mycobiotas new to the Mycotaxon website

Abstract — Mycotaxon is pleased to announce one new species distribution list to our 'web-list' page covering ascomycete and basidiomycete diversity in Yozgat province, Turkey (by Ibrahim Türkekul & Hakan Işik). This brings to 124 the number of free access mycobiotas now available on the Mycotaxon website: http://www.mycotaxon.com/resources/weblists.html

Mid-East

Turkey

Ibrahim Türkekul & Hakan Işik. Contribution to the macrofungal diversity of Yozgat province (Turkey). 27 p.

Abstract—In this study, samples of microfungi collected from Yozgat (Turkey) between 2010-2014 were examined. A total of 195 taxa belonging to 45 families were identified, of which 20 represent *Ascomycota* and 175 represent *Basidiomycota.*

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Book reviews and notices*

Abstract—Books reviewed include: *Basidiomycetes*—The fungal flora in southwestern Japan: agarics and boletes (Terashima with Takahashi & Taneyama (eds) 2016); General—Atlas of Chinese macrofungal resources (Li, Li, Yang, Tolgor & Dai 2015).

Basidiomycetes

The fungal flora in southwestern Japan: agarics and boletes. By Y. Terashima (supervisor), H. Takahashi and Y. Taneyama (eds). 2016. Tokai University Press, 4-1-1 Kitakaname, Hiratsuka-sh kanagawa 259-1292, Japan. ISBN 978-4-486-02085-1. In English and Japanese. i-xii, 351 pp, 283 figs. Price: ¥ 11,000.

This beautifully executed book gives descriptions of 35 mushroom species that were found in the Ryukyu Islands (Okinawa prefecture), which stretch from Taiwan to Kyūshū. The climate of these islands is humid subtropical in the north to tropical rainforest in the south, and the vegetation reflects that on mainland Asia.

A very short introduction to the area and the methods used in the book are followed by the taxonomic part in which the species are treated. Besides extensive and thorough morphological descriptions, the outstanding colour photographs, and line drawings of high to low quality, ITS or LSU sequence analyses are provided for many (not all) species. The authors describe 21 taxa as new. Literature references follow the species descriptions, and an index to the species is given at the end. The whole book is bilingual, with all text available in English and Japanese.

This book is a great addition to the knowledge of the mycoflora of the Ryukyu Islands.

* Book reviews or books for consideration for coverage in this column should be sent to the *Editor-in-Chief* at editor@mycotaxon.com or 6720 NW Skyline, Portland OR 97229 USA.

It is a huge step forward to see molecular data also included in this floristic approach, although this is not the first of such efforts (e.g., Desjardin & Perry 2016 for *Hypholoma* from São Tomé and Principe).

However, no explanation is provided for the selection of taxa for comparison of the mycenoid taxa in the phylogenetic analyses, and the same phylogenetic tree is reproduced seven times for various new mycenoid taxa.

Unfortunately, the names applied to the species, the generic placement of the new taxa, and the lack of comparisons with existing literature reduce the value of this book considerably. Some examples:

The newly described *Aureoboletus liquidus* is identical, in LSU sequence and morphology, to *Boletellus longicollis*. *Boletus virescens,* which is clearly a member of the xerocomoid clade, is placed in *Boletus*. The *Cruentomycena orientalis* ITS sequence is 99% identical with that of *C. kedrovayae* from coastal eastern Russia, northeast of Korea, and morphological differences between the two taxa are subtle to non-existent. The two new species *Marasmiellus lucidus* and *M. venosus,* which have very similar ITS sequences, belong in the *Neonothopanus/Omphalotus* lineage, not in *Marasmiellus,* and should be compared with *Neonothopanus nambi*. *Micropsalliota cornuta* refers to *Agaricus crocopeplus*, and it is very likely that the newly described *Mycena comata* was earlier described as *M. auricoma* by one of its authors in 1999 (Takashi 1999). *Mycena flammifera* is clearly the same as *Filoboletus manipularis*, and *M. luxfoliata* has morphological and molecular characters that fit the genus *Resinomycena*. It should also be noted that *Pleurotus* is not known for bioluminescence, and the placement of the new bioluminescent species *Pl. nitidus* in this genus should be reconsidered.

With the available sequence data these mistakes could easily have been prevented; this reviewer is not an expert on any of these groups, but by simply applying BLAST to the sequences, comparing the phylogenetic trees, and critically comparing descriptions and reading the literature, these conclusions could be drawn.

In short, a beautiful book filled with information about 35 southeast Asian mushroom species, of which a number are unfortunately misnamed.

Desjardin DE, Perry BA. 2016. Dark-spored species of *Agaricineae* from Republic of São Tomé and Príncipe, West Africa. Mycosphere 7: 359–391. http://dx.doi.org/10.5943/mycosphere/7/3/8

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General

Atlas of Chinese macrofungal resources. By Y. Li, T.H. Li, Z.L. Yang, B. Tolgor, and Y.C. Dai. 2015. National Publication Foundation. ISBN 978-7-5542-1256-1. 1351 pp, numerous colour photos. Price CNY £1480.00 [in Chinese, with Latin names]

There is only one word fit for this book: monumental. It weighs at least 5 kg, is 243 x 315 x 65 mm, has a soft cover and comes in a fancy box, and most importantly gives photos and short descriptions of 1819 species of fungi occurring in China.

The text of this book is in Chinese, and only a very brief introduction and chapter headings are in English.

A short history of mycology in China, an overview of classification of fungi, and a long chapter on different regions and vegetation types in China precede a pictorial key to different fungal types and their microscopical characters, a brief mention of the cultivated species, and then the classification used in this book followed by the bulk consisting of pages of photos, alphabetical by group, and concluded by a glossary, list of references, and indices to the species.

Because the team of authors is expert in different fungal groups, ascomycetes, polypores, and agarics are very well represented. Many species are depicted with multiple photos, with some photos spanning two pages, and they are in general of high quality. All species are apparently vouchered. Many have not been illustrated before, and a high number of species described from China are included, of which 260 were authored by one or more of this volume's authors. It was fascinating for me to see pictures of *Lepiota shixingensis* and *L. squamulosa*.

Of course, in a book of this size, there are mistakes. Some species are clearly misidentified. The photo of *Mycena sanguinolenta* in fact shows *M. haematopus;* the two *Cystolepiota seminuda* photos show a specimen with a relatively thick stipe, and I doubt that this is the same as the species described from Europe; *Baeospora myosura* from Europe is characterized by very crowded lamellae, but the number of lamellae shown in the Chinese specimen is quite low; the species depicted here as *Loreleia postii* has big, yellow-orange-brown fruitbodies, but the European species has small orange fruitbodies with pale lamellae and always grows on thallose liverworts. Finally, the genus *Pluteus* definitely needs more work in China, as *P. umbrosus* is presented several times under different names, and the *P. plautus* group needs re-assessment in general (not just in China). One of the obvious textual mistakes is the author reference for *Leucopholiota lignicola*.

Some photos really stand out: the *Pluteus thomsonii* specimen shows the most spectacularly veined pileus I've ever seen. *Clitopilus crispus* is fascinating with its irregular pileus margin and ridges. And, of course the many *Cordyceps* (s.l.) species are always awe-inspiring.

Another huge achievement of this book: the polypores are very well represented, undoubtedly thanks to the fifth author and his work.

It is really nice that photos of mushrooms in cultivation are included as well; very impressive is the field of bags with *Auricularia heimuer*! Photos of *Hericium erinaceus* in the field and in cultivation are very nice for comparison.

And lastly, some larger plant pathogenic fungi, such as corn smut (*Ustilago maydis*), *U. esculenta*, *Gymnosporangium asiaticum* on *Juniperus* and a rosaceous host, and *Sclerotinia* on sunflower, are presented.

I'll spend lots of time looking through this book, and although I cannot read Chinese, I can certainly enjoy the photos and learn the names of the many taxa I have never seen in my life.

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Book Announcements

***Agaricus* of North America.** By R.W. Kerrigan, 2016. Memoirs of The New York Botanical Garden Volume 114. New York Botanical Garden Press, <www.nybgpress.org>. ISBN 978-0-89327-536-5. Price $127.99.

***Hebeloma* (Fr.) P. Kumm.** By H.J. Beker, U. Eberhardt & J. Vesterholt†, 2016. Fungi Europaei 14. Candusso Edizioni, <www.edizionicandusso.it>. ISBN 978-88-96059-42-5. pp. 1232, many colour photos. Price € 86.00.

Mushrooms of the Redwood Coast. A comprehensive guide to the fungi of coastal northern California. By N. Siegel & C. Schwarz, 2016. Ten Speed Press, Berkeley, <www.tenspeed.com>. ISBN 978-1-60774-817-5. pp. 601, many colour photos. Price US $35.00.

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Nomenclatural novelties and typifications proposed in Mycotaxon 131(2)

Annulohypoxylon parvodiscum K.S. Cruz & Cortez [MB 812745], p. 398

Asterolibertia moquileae (Bat. & H. Maia) J.L. Bezerra, Firmino, S.P.B Araújo & Jad. Pereira [MB 805756], p. 368

Atrosynnema J.W. Xia, X.G. Zhang & Z. Li [MB 816966], p. 288

Atrosynnema digitosporum J.W. Xia, X.G. Zhang & Z. Li [MB 816967], p. 288

Bactrodesmium simile R.M. Arias, Heredia & R.F. Castañeda [MB 808325], p. 292

Codinaea leomaiae M.A. Barbosa, Malosso & R.F. Castañeda [IF 551859], p. 424

Dictyoaquaphila unisetulata R.M. Arias, Heredia & R.F. Castañeda [MB 808327], p. 292

Dictyoceratosporella wuzhishanensis J.W. Xia & X.G. Zhang [MB 817802], p. 419

Dictyochaeta brachysetula Y.L. Jiang & T.Y. Zhang [MB 815281], p. 387

Dictyochaeta chinensis Y.L. Jiang & T.Y. Zhang [MB 815282], p. 387

Flavodon ambrosius D.R. Simmons, You Li, C.C. Bateman & Hulcr [MB 813875], p. 279

Fuscopannaria rugosa H.J. Liu & J.S. Hu [MB 812172], p. 456

Gymnosporangium huanglongense Y.M. Liang & B. Cao [MB 814684], p. 378

Helicoma jianfenglingense J.M. Gao & X.G. Zhang [MB 817482], p. 352

Hemicorynespora obovoidea Jian Ma & X.G. Zhang [MB 814891], p. 263

Humicola chinensis Y.L. Jiang & T.Y. Zhang [MB 801834], p. 270

Humicola irregularis H.F. Wang & T.Y. Zhang [MB 801836], p. 271

Humicola pyriformoides J.J. Xu & T.Y. Zhang [MB 801837], p. 273

Humicola tibetensis Y.H. Geng & T.Y. Zhang [MB 801838], p. 273

Linkosia aquatica L.B. Conc., M.F.O. Marques & R. F. Castañeda [MB 815293], p. 298

Morchella conifericola Taşkın, Büyükalaca & H.H. Doğan [MB 813590], p. 478

Morchella fekeensis H.H. Doğan, Taşkın & Büyükalaca [MB 813587], p. 472

Morchella magnispora Büyükalaca, H.H. Doğan & Taşkın [MB 813588], p. 475

Morchella mediterraneensis Taşkın, Büyükalaca & H.H. Doğan [MB 813585], p. 469

Phaeodactylium cymbisporum P.M.O. Costa, Malosso & R.F. Castañeda [IF 551860], p. 437

Pseudocercospora picrasmicola Y.L. Guo, F.Y. Zhai & Ying J. Liu [MB 810159], p. 326

Stachybotryna longispiralis P.M.O. Costa, Malosso & R.F. Castañeda [IF 551861], p. 430

Solicorynespora jinggangshanensis Jian Ma & X.G. Zhang [MB 814892], p. 265

Solicorynespora lushanensis Jian Ma & X.G. Zhang [MB 814893], p. 266

Suillus alpinus X.F. Shi & P.G. Liu [MB 816992], p. 307

Suillus aurihymenius X.F. Shi & P.G. Liu [MB 817116], p. 310

Umbilicaria esculenta (Miyoshi) Minks 1900
≡ *Gyrophora esculenta* Miyoshi 1893 (lectotypified), p. 410

Wardomyces microsporus Y.L. Jiang & T.Y. Zhang [MB 815283], p. 389

Xylohyphopsis aquatica J.E. Huang, H.Y. Song, Jian Ma & D.M. Hu [MB815392], p. 392

Morchella fekeensis sp. nov.
(Taşkın & al.— Figs 5–7, p. 473)